UNIV. OF MICH.

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See page 17. 7263

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See Full Page Advt., page 82, Sept. 19.

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See Advertisement page 90. 2409

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See Full Page Advertisement, Sept. 19.

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See half-page Advert. last week and next week. 7826

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See half-page Advertisement page 96, Oct. 3.

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TO PIPE FOUNDERS.

THE CORPORATION OF GREENOCK (Water Department) invite

Tenders for the Supply and

DELIVERY at Greenock of about 530 Tons of 23 in. dia. Cast-Iron PIPES and SPECIAL CASTINGS.

Specification and Form of Tender may be obtained at the Office of the WATER ENGINEER, Municipal Buildings, on payment of a deposit of £1, which will be returned on receipt of a *bona-fide* Tender.

Sealed Tenders endorsed outside "Cast-Iron Pipes" are to be lodged with the undersigned not later than 31st October, 1919.

ANDREW NIMMO, Town Clerk.

Municipal Buildings, Greenock.
30th September, 1919. A 794

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD (PLANT AND MACHINERY SECTION).

ENGINES.

FOR SALE BY PUBLIC TENDER.

Tenders are Invited for :—

SEMI-DIESEL MARINE ENGINES with usual accessories, tools and spare parts (but no propellers or shafting).

Three 76 B.H.P. Petter two-cylinder Air Reverse Engines. Makers, Messrs. Petter.

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One 80 B.H.P. two-cylinder Coates Engine, Clutch Reverse. Makers, J. F. Coates.

Two 80 B.H.P. two-cylinder Engines, Clutch Reverse. Makers, J. F. Coates.

DIRECT REVERSING SULZER MARINE TYPE DIESEL ENGINES.

Two 450 B.H.P. four-cylinder Engines, with Auxiliary Pumps and Starting Apparatus. One right hand and one left hand. Makers, Sulzer Bros., Switzerland.

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NON-REVERSIBLE SULZER ENGINES (LAND ENGINES).

One 95 B.H.P. four-cylinder Engines with Starting Apparatus, Right Hand. Makers, Sulzer Bros., Switzerland.

Two 80 B.H.P. three-cylinder Engines with Starting Apparatus, both Right Hand. Makers, Sulzer Bros., Switzerland.

Tenders close Ten a.m., 6th November, 1919.

For Tender Form and Permit to View apply to the CONTROLLER, D.B.1.(E), Charing Cross Embankment Buildings, London, W.C. 2.

NOTE.—*Surplus*, price 3d. The Official List of Government Property for sale. Published twice monthly. On sale everywhere. A 772

BOROUGH OF WEYMOUTH AND MELCOMBE REGIS.

CONSTRUCTION OF DAM AND EMBANKMENT ROAD AND OTHER WORKS.

Extension of Time for Delivery

OF TENDERS. Owing to the Railway strike the latest date on which Tenders for the above work can be handed in has been extended to TUESDAY, NOVEMBER 4th.

FREDK. FRENCH, Town Clerk.

Weymouth,
3rd October, 1919. A 828

SOUTH STAFFORDSHIRE WATERWORKS COMPANY,
Maple Brook Pumping Station.

CONTRACT No. 5.

The Chairman and Directors invite

Tenders from Engineering

Firms for SUPPLYING and ERECTING a Vertical Triple Expansion PUMPING ENGINE with Force Pumps and Borehole Pumps to be erected in the existing Engine House at their Maple Brook Pumping Station, near Lichfield.

The plant to be capable of pumping 2,000,000 gallons per 24 hours against a total head of 512 ft., including friction.

Forms of Tender, copies of Conditions, Specification and Plans may be obtained from the undersigned.

The lowest or any Tender will not necessarily be accepted.

FRED. J. DIXON, M.Inst.C.E., Engineer.

1st October, 1919,
26a, Paradise Street,
Birmingham. A 692

MANCHESTER CORPORATION WATERWORKS.

HYDRAULIC POWER SUPPLY.

The Waterworks Committee invite

Tenders for One Set of Elec-

TRICALLY-DRIVEN HIGH-PRESSURE CENTRIFUGAL PUMPS, to deliver against a pressure of 1120 lbs. per sq. in.

Specification and form of Tender may be obtained on application to the Secretary, Waterworks Offices, Town Hall, Manchester, on payment of two guineas per copy, which sum will be returned on receipt of a bona-fide Tender. Any other information respecting the work may be obtained from the Water Engineer, Town Hall, Manchester.

Tenders must be delivered not later than the 31st October, 1919.

By order, THOMAS HUDSON, Town Clerk.

Town Hall,
Manchester.
4th October, 1919. A 829

THE ROHILKUND AND KUMAON RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply and

DELIVERY of :—
22,550 PAIRS STEEL FISHPLATES,
as per Specification to be seen at the Company's Offices.

Tenders addressed to the undersigned, and marked "Tender for Fishplates," are to be lodged not later than Noon, on Monday, the 20th day of October, 1919.

For each Specification a fee of 10/- will be charged, which cannot, under any circumstances, be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By order of the Board, H. A. NEVILLE, Secretary.

237, Gresham House,
Old Broad Street,
London, E.C.,
3rd October, 1919. A 844

COUNTY BOROUGH OF BELFAST.

TO CONTRACTORS.

The Electricity Committee invite

Tenders for Structural Steel

WORK for the new Harbour Power Station, Belfast.

Drawings can be seen and Specification, General Conditions, and Bill of Quantities obtained at the Office of the City Surveyor, City Hall, Belfast, on payment of two guineas, which will be returned on receipt of bona-fide Tender.

Sealed Tenders on forms provided, endorsed "Structural Steel Work," to be lodged in my office before Eleven o'clock a.m. on 21st October, 1919.

An official receipt must be obtained for each Tender delivered by hand. Tenders sent by post must be registered.

The lowest or any Tender will not necessarily be accepted. A 854

R. MEYER, Town Clerk.

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD.

Boring Lathes for Sale by

PUBLIC TENDER.

Two 15½ in. centre, single-ended, straight bed, Boring LATHES, length of bed 33 ft. 6 in., belt drive, six positive feeds through gear box. Makers :—T. White & Co., Paisley, Reference No. M.K. 7891 & 2.

One 18 in. centre Boring LATHE, cast-steel face-plates, provided with four adjustable jaws, driven by 30 B.H.P. motor, 220 volts, D.C., total length over bed 66 ft., approximate weight 36 tons. Makers :—Craven & Co., Manchester. Reference No. M.K. 7890.

Lying at Messrs. Walter Somers & Co., Heywood Forge, Halesowen.

Tenders for the above must be received not later than Ten a.m. 28th October.

Tender Forms and Permits to view, and all further information can be obtained on application to the CONTROLLER, D.B.1.e., Charing Cross Embankment Buildings, W.C. 2.

NOTE.—*Surplus*, price 3d., the official list of Government property for sale. Published twice monthly. On sale everywhere. A 888

THE BOMBAY, BARODA AND CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Friday, 17th October,

Tenders for the Supply of :—

TIE BARS for CAST-IRON SLEEPER POTS.

Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 20s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG, Secretary.

Offices :—110, Bishopsgate, London, E.C.2.
8th October, 1919. A 887

APPOINTMENTS OPEN.

A Large Firm of Engineers

in the Midlands have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4359, Offices of Engineering.

ROYAL TECHNICAL INSTITUTE, SALFORD.

Principal—B. Prentice, D.Sc., Ph.D.

Wanted, Temporary Assis-

TANT LECTURER in Architectural Drawing (Structural Steelwork experience desirable). Salary according to qualifications and experience. Forms of application, which should be returned not later than October 28th, may be obtained from the SECRETARY, Education Office, Chapel Street, Salford.

L. C. EVANS, Town Clerk. A 809

CITY OF CARDIFF EDUCATION COMMITTEE.

THE TECHNICAL COLLEGE.

Principal—Charles Coles, B.Sc. (Lond.).

The Services are Required of

an INSTRUCTOR in Engineering Workshop Practice, who must be a well-qualified craftsman with preferably teaching and laboratory experience. Commencing salary £350 per annum.

Applications on foolscap paper, stating age, full qualifications and experience, and giving copies of not more than three testimonials, should reach the PRINCIPAL on or before Saturday, October 18th.

JOHN J. JACKSON, B.A., Director of Education.

City Hall,
Cardiff. A 726

NEWCASTLE-UPON-TYNE EDUCATION COMMITTEE.

RUTHERFORD TECHNICAL COLLEGE.

Applications are Invited for

the undermentioned LECTURESHIPS :—
(a) Mathematics and Physics.
(b) Practical Mathematics and Mechanics.
(c) Engineering subjects.

Candidates should have the following qualifications :—

In the case of (a), a University or Technical College Education with a University Degree or its equivalent, practical experience in the work of a Physics Laboratory and teaching experience.

In the case of (b), good training in a University or Technical College and some experience of teaching.

In the case of (c), good training in a Technical College or equivalent institution in Theoretical and Laboratory work in Engineering Science, a Diploma or Certificate of Proficiency and experience in Engineering works and of teaching.

Applications, *stating salary required*, to be made to the undermentioned not later than the 18th October, 1919. Forms may be obtained upon receipt of a stamped addressed foolscap envelope.

THOS. WALLING, Acting Director of Education.

Education Office,
Northumberland Road, Newcastle. A 847

THE TECHNICAL COLLEGE, LOUGHBOROUGH.

H. SCHOFIELD, M.B.E., B.Sc., A.R.C.Sc., A.M.I.C.E., Principal.

Applications are Invited for

the following VACANCIES on the Staff of the Engineering Departments of the above College.

(a) CHIEF DRAUGHTSMAN.
The person appointed will be responsible for the control of the Engineering Drawing Office and the instruction given in this subject to Day Engineering Students. He will also be required to design various classes of machinery and scientific apparatus as is from time to time required.
It is regarded as essential that candidates shall have received a good engineering and general education, shop experience, and have held an executive position in the Drawing Office of an Engineering Works of repute.
Commencing salary £350 per annum.

(b) AUTOMATIC SHOP SUPERINTENDENT.
Candidates must have received full workshop training and be familar with the operation of all classes of Automatic and semi-automatic Turning and Screwing Machines.
Commencing salary £350 per annum.

(c) ASSISTANT INSTRUCTOR IN GENERAL MACHINE SHOP.
Candidates must have received a full workshop training and be conversant with all classes of machine tools.
Commencing salary £235 per annum.

(d) ASSISTANT INSTRUCTOR IN ELECTRIC FITTING AND SWITCH-GEAR DEPARTMENT.
Candidates should possess theoretical and practical knowledge of the manufacture of switch gear, dynamos, etc.
Commencing salary £235 per annum.

Applications, together with copies of not more than three recent testimonials, should be sent to the PRINCIPAL, at the College, not later than the 24th October, 1919. A 805

COUNTY BOROUGH OF BARROW-IN-FURNESS.

Technical and Junior Technical Schools.

Principal—D. Hardman, M.Sc.

Applications are Invited for

POST of TEACHER of Engineering Subjects (Graduate or Equivalent qualifications).
Salary—Min. £240; Max. (according to scale) £450.
Commencing salary based on experience and qualifications.

Further particulars may be obtained from the DIRECTOR OF EDUCATION, Town Hall, to whom applications should be forwarded on or before 18th October, 1919.

By Order, L. HEWLETT, Town Clerk and Clerk to the Local Education Authority.

Town Hall,
2/10/1919. A 795

ROYAL AIR FORCE.

TEMPORARY EDUCATIONAL APPOINTMENTS.

The Services of Ten

TEACHERS are REQUIRED for duty in the Royal Air Force Training Establishments for Boy Mechanics.

Candidates should be qualified to give instruction in some or all of the following subjects :—
Practical Mathematics.
Applied Mechanics.
General Elementary Science.
Mechanical Drawing.
English and Civics.

Salary at the rate of £250 per annum.

Applications, together with copies of not more than three recent testimonials, and a statement of age, educational training, qualifications, and experience, together with the names of two referees, should be forwarded to the SECRETARY, Air Ministry, Kingsway, W.C. 2, on or before 18th October, 1919. A 816

BRISTOL EDUCATION COMMITTEE.

TEMPLE JUNIOR TECHNICAL SCHOOL (ENGINEERING).

Required, to Commence Duties

as soon as possible, an ASSISTANT MASTER, well qualified in Physics, Applied Mechanics, and Practical Mathematics. Qualifications and experience in other subjects should be specified.

Salary £300 per annum, rising by annual increments of £10 to £320 (maximum for graduates, £340). Previous service in a similar capacity will be credited in fixing initial salary up to 10 years.

Forms of application, which must be returned not later than Saturday, 18th October, may be obtained by sending a stamped addressed foolscap envelope to the undersigned.

WM. AVERY ADAMS, Secretary for Education.

Guildhall, Bristol.
4th October, 1919. A 845

COUNTY BOROUGH OF WEST HAM.

MUNICIPAL TECHNICAL INSTITUTE, Romford Road, Stratford, E. 15.

Applications are Invited for

the following POSTS :—

CHIEF LECTURER in Electrical Engineering; salary (including War bonus) £300 per annum, rising by annual increments of £10 to a maximum of £450 per annum.

DEMONSTRATOR in Engineering; salary £160 per annum (rising by annual increments of £10 to a maximum of £180 per annum) plus War bonus.

ASSISTANT LECTURER in Chemistry; salary £200 per annum (rising by annual increments of £10 to a maximum of £300 per annum) plus War bonus.

The present rate of War bonus is £50 per annum.

Application Forms and further particulars may be obtained from the PRINCIPAL on receipt of stamped addressed foolscap envelope.

Applications, with copies of recent testimonials, should be sent to the PRINCIPAL, Municipal Technical Institute, Romford Road, Stratford, E. 15, not later than 14th October, 1919.

GEORGE R. HILLEARY, Town Clerk.

Education Department,
95, The Grove, E. 15.
25th September, 1919. A 721

ASSISTANT CARRIAGE AND WAGON SUPERINTENDENTS, INDIAN STATE RAILWAYS.

THE SECRETARY OF STATE FOR INDIA, will in 1919, make

Two Appointments of

ASSISTANT CARRIAGE and WAGON SUPERINTENDENTS for service on Indian State Railways, on a commencing salary of Rs. 300, Rs. 400, or Rs. 450 per mensem according to qualifications.

Candidates must be British subjects of not more than 28 years of age, and must be of good character and sound physique. They must have had a good general and technical education, and have served as pupils or apprentices in the Carriage and Wagon or Locomotive Shops of a Railway Company, or in the Carriage Shops of a large rolling-stock builder, followed in either case by at least a year's experience as outside assistant in the Carriage and Wagon Department of a British Railway. A knowledge of applied mechanics and the nature and composition of all materials used in shops is essential, and applicants should be able to design and to calculate the stresses on the parts of the machines. Some drawing office experience is also desirable.

Candidates may be required to appear before a Selection Committee at the India Office. They will also be required to pass a medical examination, if selected for appointment.

The Regulations in respect of the appointments and Forms of Application for use by candidates can be obtained on application to the SECRETARY, Public Works Department, India Office, Whitehall, London, S.W. 1. Applications for appointment must reach the India Office not later than 31st October, 1919.

India Office,
August, 1919. A 263

A MARINE-ENGINEERING WORKS LABORATORY.

The value of the aid of the scientist in solving the many problems arising in industrial work, is now becoming more generally recognised by the Government and public alike. It has, however, long been appreciated by most of the larger and more enlightened engineering firms in this country. A number of such firms have for many years been possessed of well-equipped laboratories, capable not only of carrying out all the routine testing work necessary to determine the quality of, and the best methods of utilising, the materials they employ, but also of conducting prolonged researches into the causes of failures and of fully investigating almost any of the problems in connection with their work.

One such firm is Messrs. Scott's Shipbuilding and Engineering Company, Limited, of Greenock, whose works laboratories are illustrated on the present page and page 482. These laboratories comprise three rooms, all of which are conveniently situated under one roof and on one floor. On passing into the building the first room entered is devoted to the mechanical testing of metals. It contains a 50-ton Buckton testing machine, illustrated in Fig. 1, annexed. This machine is of the screw type, and is driven by a separate electric motor. As shown, it is fitted for a bending test, but it can, of course, also be used for ordinary tests in tension and compression. The autographic recording apparatus fitted can be distinguished in the illustration just below the counterpoise. The chemical laboratory, which adjoins the mechanical testing room, is illustrated in Figs. 2 and 3, on page 482. It is mainly employed on general routine work, and particularly on analysis. The equipment includes a Sand's rotating apparatus for electrolytic analysis, an electric drying oven, a Boverton Redwood viscometer, a Gray oil flash-point apparatus, a Humfrey carbon combustion furnace, and a Richmond muffle furnace. Most of these, with the usual collection of glassware, can be distinguished in our illustrations. Opening off the chemical laboratory are an office and library, and a balance room. The latter contains two Oertling balances, and is also fitted up as a store room for chemicals and glass apparatus. The physical laboratory, which is also connected with the chemical laboratory, is shown in Figs. 4 and 5, on page 482. Fig. 4 illustrates the horizontal metallurgical microscope, by Watsons, which can be used for visual or photographic work. The arc lamp and optical bench for vertical illumination can be seen on the left of the illustration, and the photographic camera on the right. Two electric resistance furnaces for heat treatment work, and a Brinell hardness testing machine, with which the laboratory is provided, are shown in Fig. 5. The equipment also includes a number of standard thermo-couples, a Siemens' galvanometer for recording work, and a Cambridge optical pyrometer. A portion of this laboratory is partitioned off for use as a photographic dark room.

The work carried on in these laboratories is of the varied character associated with a large shipbuilding and engineering establishment. In the testing department, steels, cast-irons, gunmetal and other copper alloys, as well as manufactured products such as boiler tubes, are subjected to a variety of tests to ascertain their quality and suitability for the purposes for which they are to be employed. In connection with the foundry, analyses are made to test the purity of the various metals and alloys used, and also to check the composition of the finished castings; defective castings are also examined microscopically. All scrap materials, such as gates, runners, cuttings and borings, are melted and re-cast into ingots, which are analysed and used according to the results of these analyses. To ensure the continuous production of sound and reliable castings, investigations are made from time to time on casting temperatures and rates of cooling, and from the results of such investigations a system of temperature control is maintained. Temperatures are controlled by a large number of pyrometers throughout the works, and one of the duties of the laboratory staff is to check the works instruments against the laboratory standards. The determination of the composition, and qualities of various tool steels used constitutes another branch of the laboratory work, and experiments are also conducted to ascertain the best method of heat treatment for

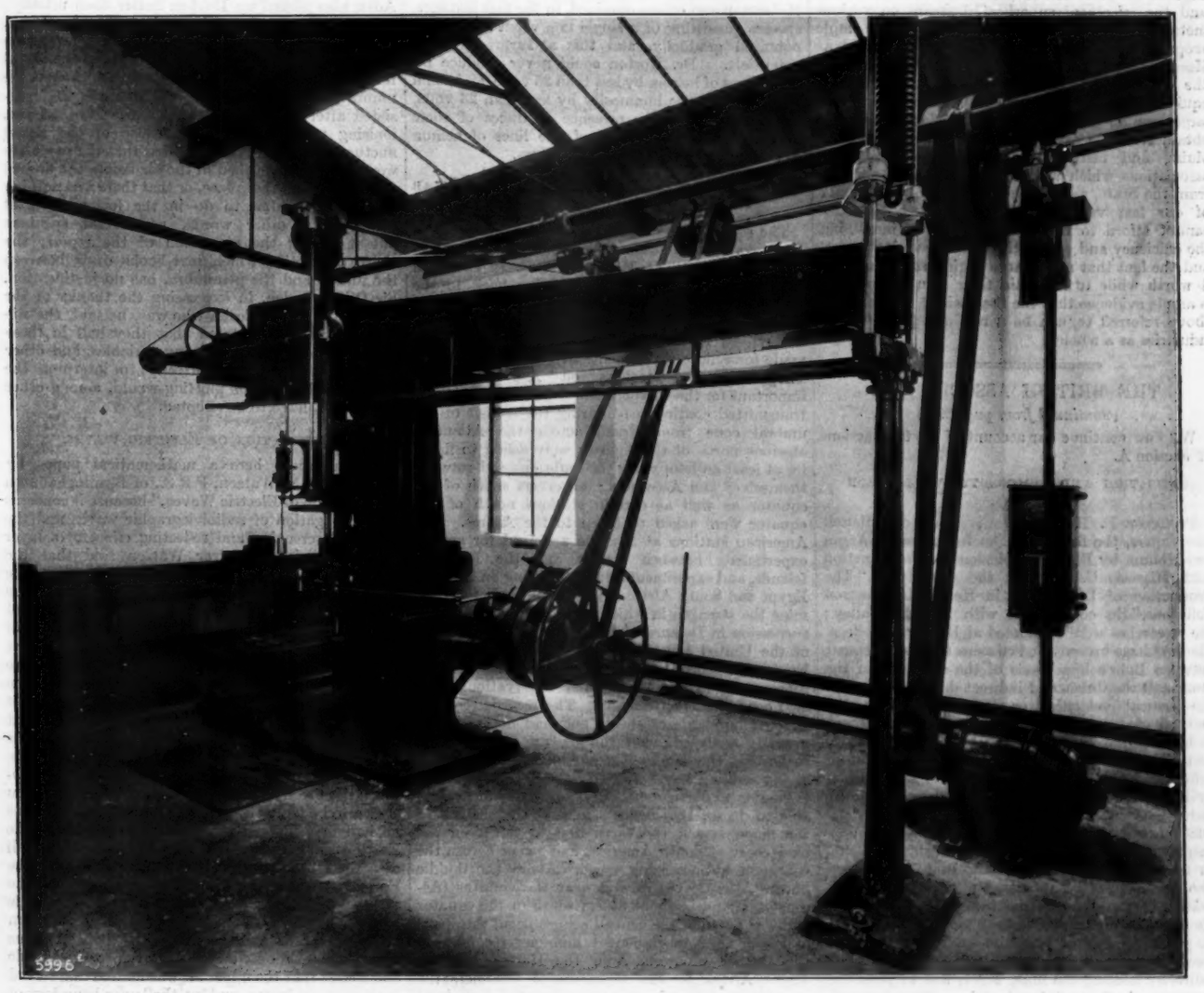


Fig. 1. 50-Ton Buckton Testing Machine.

each grade of steel; case-hardening is another matter which is scientifically dealt with. The work from the shipyards consists mainly of testing the iron and steel used for constructional purposes, and includes the investigation of failures of plates and welds, and testing the strength of welds, as well as the determination of the composition and purity of paints, oils, greases, rubber, insulation, and other non-metallic materials used in shipbuilding.

In addition to the foregoing work researches are carried on in connection with cast irons required for the cylinders and liners of internal-combustion engines, the corrosion of boiler and condenser tubes, and the effects of superheated steam on various metals and alloys, so that there is evidently ample scope for laboratory work in a large concern such as Messrs. Scott's. It will be obvious, however, that the cost of a highly-trained staff and elaborate equipment can only be borne by a firm having a large annual turnover. Smaller firms can best obtain scientific assistance in their work by combining and instituting, or supporting, research associations which will receive financial assistance from the State, as explained on pages 316 and 317 of our last volume. At the present time we cannot afford to neglect any means of increasing the efficiency and productiveness of our industries, and the fact that many large engineering firms find it worth while to maintain their own laboratories is ample evidence that the State-aided laboratories, above referred to, can be a real assistance to the industries as a whole.

THE BRITISH ASSOCIATION.

(*Continued from page* 399.)

We now continue our account of the transactions of Section A.

Ionisation and Luminosity by Electron Collisions.

Professor F. Horton, M.A., D.Sc., contributed two papers, the first on "The Ionisation of Argon and Helium by Electron Collisions," in conjunction with Miss A. C. Davies; the second on "The Production of Luminosity in Helium by Electron Collisions," in conjunction with Miss D. Bailey; the researches were conducted at Holloway College. The problems investigated concern the disagreement between Bohr's hypothesis of the structure of the atom and the direct and indirect determinations of the critical velocities or volts. Applying the method of Lenard, Professor Horton pointed out in his first paper, Franck and Hertz had, in 1913, first observed a minimum ionisation potential of helium of 20·5 volts, and this value was confirmed by Pawlow, Bazzoni and others, whilst the indirect deductions of Aston and others, relying upon the relation $e\,V = h\,\nu$ (h = Planck's constant, ν = frequency) gave Bohr's theoretical value 29 volts. In redetermining the potentials, Professor Horton also made use of an apparatus of the Lenard type, heating a tantalum filament in a vacuum bulb. He gave the filament first the shape of an inverted V, placing a disc of platinum foil, with a central speck of lime, on the top of the apex, and thus indirectly heating the lime, which was to yield the electrons. As the tantalum had, in continued experiments, to be heated to very high temperatures, however, he dispensed with the foil and placed only three sheets of platinum gauze, charged to various potentials, at different levels above the filament. The whole tube was wound with a magnetising coil, and a confined central stream of electrons was thus obtained. The distinction between radiations and ionisation was made after Davis and Goucher (experimenting on mercury vapour, *Physical Review*, August, 1917); the light radiation from the filament might itself cause ionisation, but that emission would be negative, whilst the ionisation yielded both positive and negative particles. Dr. Horton's experiments showed that there were two critical velocities for the electrons, radiation appearing first at the lower critical velocity, and ionisation later at the higher. In argon the critical velocities corresponded respectively to potential differences of 11·5 and 15·1 volts, in helium to 20·4 and 25·6 volts. This latter value, 25·6 volts, was lower than Bohr's figure 29 volts; on the other hand, the frequency limits calculated by Professor Horton with the aid of the quantum relation agreed with the recent spectroscopic determinations of Lyman.

In the second paper, Dr. Horton described how luminosity arose when helium atoms were bombarded by electrons of gradually increased velocity. Once excited, the luminosity could be maintained by a slightly lower velocity, and it was particularly investigated whether the different series lines of helium required different minimal electron velocities for their excitation. Our readers will remember from former articles, that Franck and Hertz, and McLennan and others obtained, in the first instance, spectra consisting of a single line when raising the potential gradually, and this at surprisingly low potentials. Dr. Horton could never produce his series lines of helium by less than 25 volts, and could not maintain the luminosity by less than 23 volts, and then only in the presence of traces of some impurity; moreover, none of the lines of helium would appear singly before the others.

Radiotelegraphic Investigation and the Solar Eclipse.

The report of the Committee on Radiotelegraphic Investigations (chairman, Sir Oliver Lodge; secretary, Professor W. H. Eccles, of Finsbury Technical College) once more took the section back to the eclipse of May 29. The war-time restrictions on radiotelegraphy, Professor Eccles said in presenting the report, had continued, but the arrangements made for eclipse experiments had been carried out. The Admiralty stations on Ascension—most important for these experiments—and on the Azores transmitted continuously during the transit of the umbral cone from Brazil across the Atlantic; stations north of the equator were asked to listen for at least an hour while the umbra passed between themselves and Ascension; observers south of the equator as well as certain stations north of the equator were asked to listen to the Azores. The American stations at Sayville arranged for special experiments between Darien and the Falkland Islands, and experiments were also going on between Egypt and South Africa. It was intended to determine the strength in which signals were received in succession in Demarara, Jamaica, on the east coast of the United States and Canada and in Ireland, England, France, Spain and Italy, in the Mediterranean and in Egypt; similar observations were also conducted in Germany. The records received covered hunderds of sheets and had not yet been properly analysed; but the general result seemed to be that the eclipse had not affected the signals in any striking way.

Passing to particulars, so far as he was at present able to do so, Dr. Eccles said that the shadow of the moon struck the earth first at dawn on the west coast of South America, and swept across the continent at increasing speed. About the middle of the Atlantic Ocean and near the equator (Ascension Island is about 8 deg. south of the equator and was north of the central eclipse path) the speed of the shadow was about $\frac{1}{3}$ mile per second; in the further progress, from the Gulf of Guinea across Africa to the Mozambique Channel, the speed increased again, and the eclipse finished about sunset near Madagascar. The effects looked for were: (1) strays; they were bad on the eclipse day and previous days; meteorological conditions were exceptional in America, where rains had persisted for some weeks, and the intensity and frequency of the strays observed could not directly be ascribed to the passage of the eclipse. As regards (2) signals traversing the dense shadow, the arc signals (wave length 4,700 m.) sent out from the two Islands and observed in Europe and America, had not been of unusual character. Special attention had been paid to a possible reflecting-screen effect of the shadow; such effects had sometimes been noticed at sunset and sunrise. The stations south of the central line of the eclipse at Durban and in South-West Africa, reported no strengthening (rather a weakening) of the signals from Ascension, which (likewise south of the central line) they might have heard both directly and by reflection from the shadow screen, and similar reports had come from Malta and Rosyth, listening to Cairo (all north of the central line). As regards (3) effects on signals passing across the central line, Darien (Panama) was to communicate with the Falkland Islands, but these reports had not yet come in; other stations had failed to pick up their signals, and the service between Ascension and Demerara had fluctuated. Ships at sea within the penumbra, however, reported a strengthening of all the signals during the eclipse. The most interesting reports had been received from France, Malta and Teneriffe; Meudon and Roussillon practically heard Ascension only while the eclipse was in progress, and Malta and Teneriffe reported a great improvement. Aden also picked up Durban better than usually; on the other hand, Durban could not hear Cairo, which was usually possible. On the whole the records showed that the improvement in the signal intensity reached its highest value long before the umbra intervened between the stations, and persisted after the umbra had passed. If, therefore, ionising processes were the cause of the signal fluctuations, the results indicated that the processes were fully accomplished in the air before the arrival of the umbra at that place, or that there was nothing left for the umbra to do in the few minutes of totality. In other words, as several speakers put it during the discussion of the report, the sharp distinction which text-books draw between the umbra and the penumbra, has no justification. Sir Oliver Lodge, in expressing the thanks of the Committee to Dr. Eccles who was, he said, the life of the Committee, stated that they had in these phenomena to deal with many variables, and other speakers argued that, correctly to interpret the results, lucid ways of plotting would, among other expedients, have to be adopted.

Diffraction of Electric Waves.

We interpose here a mathematical paper by Professor G. N. Watson, F.R.S., of Birmingham, on "Diffraction of Electric Waves," because it concerns the propagation of radiotelegraphic waves and the supposed screening and reflecting effect of a layer of ionised air. Professor Watson said that the fundamental problem of the propagation of electric waves had briefly been styled diffraction by various investigators; but his phenomenon was not diffraction. He wished to determine the effect of a Hertzian oscillator near the earth's surface at various angular distances θ from the source. The mathematical problem of an approximate summation of a complicated oscillatory series had been dealt with by Macdonald, Poincaré and Nicholson, but their solutions were not in accord with observations of the strengths of signals at different θ, whilst the method of Sommerfeld's pupils (March and Rybczinski) agreed with observations, but had been shown to be faulty by Love. In his own deductions he had first made the usual assumption that the Earth was a perfect conductor surrounded by a shell of a dielectric; he had found, however, that the Earth's conductivity did not matter, because the greater portion of the disturbance travelled outside the Earth, not through it. But he had not been able to bring his results in accord with observations until he had adopted the suggestion of Heaviside and Eccles that the upper air was ionised and served both as a conductor, and, at the lower boundary of this layer, as a reflector for the waves. If h were the height of this layer above the surface and σ its conductivity, then he found $h^2\sigma = 1{\cdot}67 \times 10^{11}$. For an h of 100 km., the formula would yield a conductivity of the layer about three times as great as the conductivity of fresh water. His calculations showed that there would not be a focus of the electromagnetic force at the antipode, but the electric forces would oscillate strongly near that point. The interpretation of the results, the discussion of the paper indicated, is not simple. Sir Oliver Lodge said that we had believed the Earth to be favourable to radiotelegraphy; it now appeared that it was the atmosphere; daylight, he understood, spoiled the propagation. Dr. Eccles remarked that the suggestion of an ionised layer was an old idea, but it was satisfactory that the mathematicians supported the suggestion. To Dr. Lindemann's question whether we were to understand that the conductivity was greater at night than at daytime,

Dr. Eccles replied that in daytime the ionised layer came lower down, and the absorption was stronger; but the better night service was rather due to the permanently ionised upper layer. Dr. Lindemann objected that the phenomena seemed rather to indicate that there must be a source of ionisation in addition to the light effect. Professor Porter asked how there could be reflection as the transition from the insulating air into the ionised air would be gradual. Dr. B. van der Pool, of Utrecht (at present at Cambridge), to whom Professor Watson had referred in his paper, said that he agreed with Professor Watson that diffraction would not explain the propagation of electric waves round the Earth. He had shown (in the *Philosophical Magazine* of this September) that the facts seemed to demand a sharp inner boundary between the ionised layer and the lower atmosphere; but a sharp boundary could hardly exist, and considerable energy would be dissipated in the transition; yet the motion of free ions in an alternating field in the sense of Eccles would yield a finite conductivity as well as a diminished dielectric constant, and he thought that, admitting an increase of phase velocity with light, the observations of radiotelegraphy were compatible with a gradual ionisation without sharp boundary.

Fig. 1.

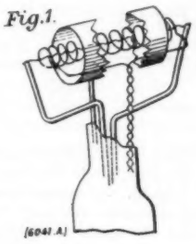


Fig. 3.

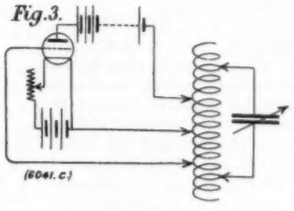


Fig. 2.

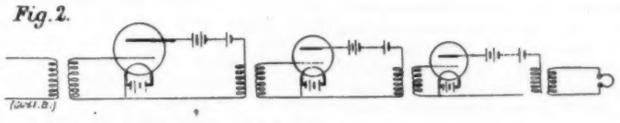
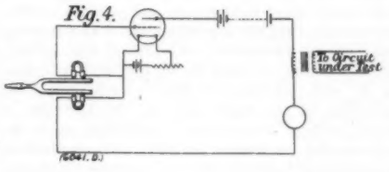


Fig. 4.



Radiotelegraphy and Thermionic Valves.

In opening this discussion, Dr. Eccles remarked that the people were not wrong in describing the revolutionary development, which had taken place in radiotelegraphy during the war, to instruments called valves, tubes, or sometimes simply lamps. The complete name was the three-electrode thermionic vacuum tube or "triode," and it was not the old two-electrode valve which had effected the change. In 1917 practically the most powerful transmitting stations had all worked with spark waves and had received by means of crystal detectors or magnetic detectors; the spark method necessitated the use of large antennae for long ranges. At present most long-distance stations transmitted by uniform uninterrupted waves, and received them by the aid of novel apparatus. Under reasonable weather conditions it was quite possible to listen to the other side of the Atlantic with the aid of a coil about 4 ft. square, and, so far as receiving was concerned, one might intercept all the big stations on one half of the globe with apparatus fitting into a cupboard. That did not abolish the antennae for reception; combined with antennae the new magnifying methods extended the ranges far beyond the possibilities of 1913, and magnifications of several hundred thousandfold were, in fact, in use. The valve served other useful purposes as well, moreover; large-size valves would produce high-frequency currents of considerable power, and the triode would also impress the human voice upon the undulatory waves.

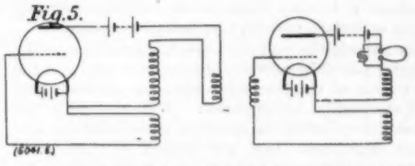
The triode contained three conductors or electrodes: (1) The "cathode" was a tungsten filament, straight or curved; heated by a battery it gave off electrons of exceedingly small inertia, and capable, therefore, of responding to the most rapid current alternations of radiotelegraphy. Electricity was hence generated without moving parts, and might be generated direct from fuel, and that opened up further possibilities. (2) The "anode" was made of large surface in order to carry appreciable currents from the vacuum to the outside. (3) The third electrode, or "grid," was to control the flow of electrons from the cathode to the anode, and was, therefore, charged electrically; when negative it repelled the negative electrons back into the filament, when positive it facilitated the expulsion of the electrons. Both the anode and grid might vary in shape and in position with respect to the cathode; Fig. 1 shows the arrangement of the French receiving pattern, which had been manufactured in hundreds of thousands. The anode was a short nickel cylinder, the cathode a small tungsten filament in it, and the grid a helical spring surrounding the wire. The filament was kept hot by a special battery, and with a main battery of 100 volts between anode and cathode, the electronic current across the vacuum would be about 1/200 ampere; the electrification of the grid would increase or decrease that current, and the responses of the main outer current to the application of a few volts to the grid were 10 and even 20 times stronger than they would be with direct application of the same number of volts to the main circuit; these magnifications could be increased many times by combining several valves in series. Further, the electric influence in one circuit could be made to act on the grid of another circuit without suffering appreciable reduction, not even so much energy being absorbed as would be used in setting a galvanometer needle into motion; that was valuable for general use in physical laboratories.

Turning to the actual ways in which valves were utilised in radiotelegraphy Dr. Eccles said that, in the amplifier, the valves were linked with one another and with the outside apparatus by transformers of various ratios, the current from the anode of the first valve passing through the primary of a transformer, the secondary of which was joined to the grid of the second valve, and so on (Fig. 2); for some purposes the amplifiers were tuned so as to obtain further magnification by resonance. Such apparatus served also for earth telegraphy, submarine listening and telegraphy by invisible means; the vibrations might be reduced to 10 or 20 per second. Some of his (Dr. Eccles') apparatus would detect alternating currents corresponding to 1/10,000,000,000 of a volt on the input side, and that had brought his thoughts back to the dream of transoceanic telegraphy by means of alternating currents delivered into the sea at the ends of long cables; with cables 50 miles long on each side of the Atlantic, capable of delivering 40 amperes at frequency 20, telegraphic communication ought to be possible.

As regards the generation of uniform electric waves all that was required was a valve and an oscillatory circuit comprising a coil and a condenser; the three electrodes of the valve were joined to three points of the coil as Fig. 3 indicates. There was no visible sign of the generation of the waves, and it was fortunate that it was difficult to go wrong in making the connections; the cathode had to be connected with the middle of the coil, not with its ends. Dr. Eccles demonstrated by a mechanical analogue the way in which the oscillations are excited; the arrangement is explained by the diagram, Fig. 4. The coils of the electromagnets acting upon the two prongs of a tuning fork, were joined, the one to the control circuit, the other to the main circuit. The movement of the one prong induced electromotive force in its electromagnet jointed to the grid circuit; the grid was then in a position to control the main current which, in its turn traversing its own magnet coils in the correct sense, helped to sustain the oscillations of the fork. The electric oscillator operated in an analogous manner, but the frequency might be raised to many millions per second.

Passing to "sub-generative" generation (Fig. 5), Dr. Eccles explained that, since the operation of the valves largely depended upon the interaction of the two portions of the coil upon each other, one could, by separating the coil, weaken the oscillations and reduce them to a state of suspense, in which the oscillations just failed to be maintained; when the valve was in that "sub-generative" state, a very feeble stimulus, if properly timed, could stimulate the system into vibration, and the resulting display was energetic far beyond the stimulus. Enormous magnifications could be realised with a single triode in this way. Many ships were fitted with this type of receiver, and by its aid spark signals could be read at amazing distances. When the experimenter passed gradually from the sub-generative state to the oscillating condition, other phenomena became apparent. If the incoming radiations to be magnified were uniform and of nearly the same audible frequency as that natural to the oscillator, the musical note in the telephone began to throb. The input required to produce this throbbing was exceedingly small; probably the input current was, on reaching the grid, first magnified as explained, and it then combined with the local oscillations to produce "beats," the beats themselves being magnified by the circuits of the triode. The phenomenon was of the nature of a true beat; for if the sustained oscillator had the frequency 400, and the incoming current a frequency of 402 or of 398, the listener in the telephone heard two beats per second, and if we went up to 402,000 oscillations per second, superposed upon 400,000 oscillations (both inaudible, of course), the telephone gave the differential beat note 2,000, as soon as the incoming current was switched on. This "autoheterodyne" method or "autodyne" reception was universally used for the reception of the continuous waves of modern radiotelegraphy. The operator set his instruments at approximately the wave-length he hoped to receive; the waves coming up to his antenna from the distant station produced minute currents which the operator heard each time the transmitter key was depressed. The local frequency could be adjusted at will, and the pitch of the beat note thus be altered to suit the ear of the receiving operator. The beat note changed very rapidly with the capacity of the condenser; hence the method was easily applicable to the measurement of changes in capacity of the order of 0·001 electrostatic unit, such as would result when coal gas was substituted for air in the condenser.

Fig. 5.



Professor C. L. Fortescue, of the Royal Naval College, Greenwich, speaking after Dr. Eccles, said that the valve had by no means reached finality, and he discussed various points requiring further investigation. In the filament the electrons were

free to move, but not free to leave, because the fields in the interatomic spaces were intense. The average kinetic energy of the electron seemed to be that of a gas molecule at the same temperature; as the temperature was raised, the electrons became free in the sense that electric fields of quite ordinary magnitude could expel them. The tungsten filament mostly used was by no means an ideal source of electrons. The electrons required something like 4·5 volts to become able to break through the boundary of the metal, and as tungsten seemed to demand about 100 watts for an emission of 1 ampere of free electrons, the efficiency of the tungsten filament was only 4½ per cent. Was tungsten then the best material? Surface contamination reduced the emission; on the other hand coatings of lime on platinum (Wehnelt cathodes) gave large emissions at 1,000 deg. C., whilst tungsten filaments had to be heated to 2,000 deg. But those coatings were very fragile, developed cracks, and became inefficient after a time, probably because they were bombarded by positive ions [Major Whiddington referred to this point subsequently.] The tungsten filament might be made more efficient by raising it to higher temperature; but the heating of the filament by the current was in itself objectionable, because the different parts of the filament were not at the same potential and the emission, therefore, was not uniform; so far, however, no other method of heating filaments of tungsten nor any other materials, carbon, *e.g.*, had given promise.

As regards the grid electrode the problems of the contact potential between filament and grid and the best form of the electrode called for mathematical and mechanical investigation. With respect to the anode (or cylinder) the question of occluded gas was most important. Gas was indeed also liberated from the other parts and the inner walls of the bulb. With high-vacuum valves and gas pressure of the order of 0·0001 mm. of mercury, the liberation of very minute quantities of gas caused appreciable ionisation effects. The present method of gas removal was of the sledge-hammer type; the valve while connected with the pump was exposed to higher temperatures and heavier bombardments than it would experience in actual use. The treatment might remove the adsorbed surface layer of gas, but hardly the intercrystalline gas, though valves sometimes did turn soft in the cold, apparently by slow diffusion of the gas; it was noteworthy in this respect that, any air readmitted into a valve and adsorbed by the electrodes, could easily be removed again. The analysis of the liberated gas had been restricted to spectrum analyses of the "blue glow" visible when the valve was overloaded, and to the determinations of ionisation potentials; both the methods gave abnormal results, and it was most desirable that other methods should be devised for examining the "electrode gas." Since valves were hardened when the volts at the positive electrode were raised, the hardening seemed to be due to the driving of the positive ions into the hot filament; but why were they retained by the hot filament? Dr. G. B. Bryan, also of the Naval College, had suggested that a positive ion, of hydrogen, *e.g.*, was a small, but heavy projectile which would be able to penetrate into the filament; picking up an electron there, it would become neutralised and too big to escape again, being entrapped among the atoms of the metal. At moderate temperature, however, the electron might be shed again, and the positive ion might then escape once more; thus a positive emission would take place. Dr. Bryan had, in this connection, drawn attention to the fact that a small liberation of occluded gas caused much more arcing in the valve than the admission of considerable quantities of air. Gas was further liberated from the glass, which was not an ideal valve material either, as it was brittle and did not admit of "cooking" at high temperature; it was difficult to seal the lead properly in glass, and glass was opaque to infra-red rays so that bulbs had to be made larger than they would if they allowed the heat to escape. Fused silica was not free from objections, either, and with the double metallic containers of de Forest the difficulty of vacuum-tight joints remained. There was need of a really good cement. Professor Fortescue mentioned that a disastrous fire at Portsmouth, which had destroyed every instrument in a cabinet, had left four out of seven valves quite serviceable, though they had been badly blackened.

Mr. B. S. Gossling, of the Osram Works, who spoke next further indicated the nature of the many problems which the valves offered. These included, he said, the effects of the mutual repulsion of the electrons emitted, the Maxwell distribution of the velocities of the electrons which were not emitted at uniform velocities, the constant potential between the body of the filament and that of the grid, and the composite electric fields produced near the filament by the grid and anode, allowance having to be made for the difference of potential between the ends of the filament and for the deflection of electrons passing near the grid wires. Even in vacua of 0·0001 mm. of mercury ionisation might be necessary for the purpose of maintaining the vacuum. They had at his works finally made valves at the rate of half a million a year, and their tests and investigations had confirmed much of the earlier research work. At first valves had been fickle, but they varied very little now. Time did not permit Mr. Gossling to go further into particulars.

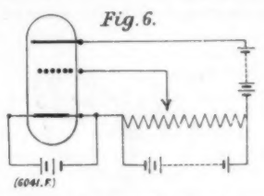
Professor R. Whiddington, M.A., D.Sc., of Leeds, who continued the discussion, drew attention to a few of the possibilities of the valve in the physical laboratory. The well-known typical oscillation circuit mentioned by Eccles could be utilised for determining the mutual induction between grid coil and anode coil. The condition was that the induction M was greater than $(L/\rho + RC)\ k$, where L was the inductance, C the capacity, R the resistance of the periodic circuit, ρ the valve resistance, and k the amplification factor of the valve; the oscillations set up in the anode circuit were then approximately $2\pi\sqrt{LC}$. In order to determine the M, the condenser C was adjusted until the oscillations ceased to be maintained; then M was nearly RC/k. Captain Turner had produced a relay valve on this principle, the M in his arrangement being just less than RC/k. A signal incident upon the system would upset the balance and produce ocsillations, thereby slightly increasing the k and making the oscillations permanent. The relay, was, in fact, not self-restoring, and had to be restored to quiescence by some mechanical device, such as a Post Office relay, in the anode circuit. If, however, a wire of positive temperature coefficient were inserted in the oscillating circuit, any oscillations produced would heat the wire and increase the resistance; a suitable resistance would extinguish the oscillations and render the relay self-restoring. Professor Eccles had referred to the extreme sensitiveness of heterodyne reception, exemplifying this by placing coal gas, instead of air, between the plates of the one condenser of his instrument. Dr. Whiddington mentioned that he had also demonstrated the effects of resistance changes with temperature in other ways, by passing a flame over the coil or by heating a loop wire of copper attached to it; the permeability of liquids and gases could be measured by placing them in tubes within the coil, and other quantitative determinations might be made on similar lines.

Sir Oliver Lodge, rising next, said that they all admired the way in which Fleming's valve had come to its own. He himself was particularly interested in the question in how far, atomic energy could be utilised. When we expelled electrons by heating the filament, the energy came from the battery; batteries were perhaps not necessary. We might utilise radioactivity or photo-electricity by illuminating a clean metal surface or by exposing it to X-rays; we really worked with radiant matter. Captain Makower (the recorder of the section) said he had tried radioactive working; he had placed a thin layer of metal over a polonium plate, the polonium to give α rays and to cause the metal to emit δ rays. Mr. S. G. Brown, F.R.S., who did not consider that de Forest had been given sufficient credit, stated that he had tried lime-coated filaments and grids also covered with lime; the effect had been good, for a time, but at 2,000 deg. C. the lime resistance was still very high. Mr. G. Stead, of Cambridge, mentioned that nitrogen was not absorbed in the valves in the absence of an electric field. Professor Eccles briefly replied to the points raised during the discussion.

Self-Oscillations in Valves and the Ratio e/m.

In this further paper Dr. R. Whiddington pointed out that the so-called French method of producing oscillations of frequency in $2\pi\sqrt{LC}$ required that the resistance R of the anode circuit was great, the resistance ρ of the grid circuit small, and the mutual induction M between the grid and anode coils only sufficiently large to maintain the oscillations. The method had been largely utilised with hard valves containing too little gas for ionisation by collision. But soft valves could similarly be used, without the aid of any capacity-inductance, merely by means of a constant source of high potential in the anode circuit and a non-inductive potentiometer in the grid circuit (Fig. 6). Strong oscillations of a frequency practically depending upon the valve dimensions and the grid potential could thus be produced on a novel principle. To

Fig. 6.



explain this action Dr. Whiddington suggested that the tungsten filament, while emitting on the whole in accordance with an exponential law, would emit electrons at an enhanced intensity from some spot or spots because the spots were being bombarded with positive ions in a way presently to be explained, Such bright spots (at which the metal might be impure) were noticed in the cherry-red filament when the anode was "cleaned up" by passing a heavy thermoionic discharge through the valve when on the pump. The electrons emitted from such a spot would reach the grid at the moderate speed u, given by the relation that the positive grid potential (with respect to the filament spot) was $V = \frac{1}{2}\ m\ u^2$, so that $u = \sqrt{2\ V\ e/m}$, where e/m was the ratio of the electron charge to its mass. After passing through the grid the electrons entered into a strong field and attained ionising speeds; the positive ions (produced by collision of the electrons with the residual gas) passed back through the grid to the filament with a speed $u_1 = \sqrt{2\ V\ e/m_1}$, where m_1 was the mass of the ionised atom or molecule. Thus the spot was being bombarded by positive ions, and this bombardment caused a new outburst of electrons, and a self-sustained oscillation was set up. Calculating the e/m and the frequencies for hydrogen and mercury vapour by measuring the lengths of the waves produced, Dr. Whiddington found that his frequencies of about $6{\cdot}6 \times 10^5$ cycles obtained with a grid potential of only 1 volt, agreed best with a residual gas consisting of monatomic mercury molecules, to which he therefore ascribed the oscillations. If polyatomic atoms were involved, the frequency value would have to be divided by $\sqrt{2}$, $\sqrt{3}$, $\sqrt{4}$, according to the number of atoms in the molecule. The experiments gave some indication also of oscillations due to oxygen and carbon dioxide. Theoretically the square of the speed of the ions should be proportional to the potential of the grid, and this was supported by his experiments, which he was continuing for the purpose of obtaining accurate values for the e/m.

In commenting upon this paper Dr. Eccles said that the method appeared very promising indeed, provided we took all precautions as to using non-inductive resistances. It was known that the filament would remain hot after switching off the battery; that supported the suggestion of a bombardment by ions. Sir Oliver Lodge concurred; at the very high frequencies involved slight changes in capacity and inductance became very important. For the electrostatic effects we wanted very high vacua, moreover; would it be possible, he asked, to work with an electromagnetic field, sending the electrons alternately to one electrode on the left and another on the right of the bulb? In reply, Professor Eccles stated that this device had been tried, but only up to frequencies of 1,000.

GEOPHYSICAL DISCUSSIONS.

We now turn to communications which may be grouped under the heading of Geophysics, and notice in the first instance the report of the Committee on "Geophysical Discussions." The Astronomer Royal, Sir Frank W. Dyson, is chairman of this committee, and Dr. Sydney Chapman, of Cambridge, its secretary. The committee reported that in accordance with the terms of reference, to arrange meetings for the discussion of papers and reports on geophysical subjects and to co-operate with existing committees in making recommendations for the study of such subjects in the British Empire, the following meetings had been held during the session 1918–19: November 19, 1918, discussion on the Constitution of the Earth Interior, opened by Mr. R. D. Oldham, F.R.S.; January 21, 1919, report on Seiches (Dr. E. M. Wedderburn) and on Tidal Motions in the Atmosphere (Major G. L. Taylor and Dr. S. Chapman); February 18, 1919, report on Seismology (Professor H. H. Turner) and account of two papers by the late Prince Galitzin (Mr. G. W. Walker, F.R.S.); March 18, 1919, discussion on Measurement by Means of Horizontal Coils of Pulsations in the Earth's Vertical Magnetic Force (Dr. Crichton Mitchell and Professor W. H. Bragg); report on a Survey of Magnetically-disturbed Localities in England and on the Geological Significance of the Disturbances (Professors H. Cox and E. Wilson); May 20, discussion on the Functions of a Geodetic Institute (Colonel Lyons, Colonel Sir C. F. Close, Sir J. Larmor, Admiral J. F. Parry, Sir F. W. Dyson and others); June 15, report on Atmospheric Electricity (Dr. C. T. R. Wilson). The meetings had been held in the rooms of the Royal Astronomical Society on the third Tuesdays of the respective months, at 5 p.m., and were to be continued. A new committee having been appointed, consisting of representatives of the following societies: Royal Astronomical, Royal Geographical, Royal Meteorological, Geological, Physical, and the British Astronomical Association, the British Association Committee did not ask for reappointment.

(To be continued.)

GEARED TURBINES IN THE SWEDISH NAVY.

CONSIDERABLE interest attaches to the turbine machinery supplied by the de Laval Steam Turbine Company to the Swedish destroyers Wrangel and Wachtmeister, the trials of which were brought to a successful conclusion towards the end of last year. These new vessels are a further development of the type previously in favour in the Swedish Navy. The seaworthiness has been improved by raising the bows of the boats, and the offensive powers by an increase in the number of torpedo tubes. The two boats are the first units of the Swedish Navy to be fitted with geared turbines, but the same type of machinery has been adopted for the battleships Gustav V and Drottning Viktoria, now in course of construction. In the case of the destroyers, the form of the resistance curve at high speeds is such that any increase of power results in a duly equivalent gain in speed, but the conditions are not as favourable in the case of the two battleships above referred to.

The following are general particulars of the destroyers' machinery as specified by the Swedish Admiralty:—

Number of propellers	2
Aggregate shaft horse-power at full power	11,000
Revolutions per minute of screws at full power... ...	450
Shaft horse-power at cruising speed	1,000
Revolutions at cruising speed	210
Shaft horse-power astern ...	4,400
Revolutions per minute astern	250
Total weight of machinery ...	37·5 tons
Steam pressure in boilers ...	256 lb. per sq. in.
Vacuum at full power	92 per cent. to 93 per cent.

With steam 97 per cent. dry, the turbines were guaranteed to consume not more than 5·2 kg. of steam per shaft horse-power hour at full load, and not more than 7·7 kg. per shaft horse-power hour at cruising speeds. It was estimated that in addition to this, the auxiliaries would require 9 tons of steam per hour at full speed, and 1½ tons of steam per hour when cruising.

The general arrangement of the machinery as fitted on board is represented in Figs. 1 to 4, page 472. As will be seen, the turbines and gears for the starboard shaft are well forward of those driving the port shaft, the two sets being staggered in the fore and aft direction. Owing to lack of available height it was not possible to arrange the condensers below the low-pressure turbines, so that large exhaust pipes have been necessary. As will be seen, the high and low-pressure turbines occupy separate casings and drive pinions engaging on opposite sides of the main gear wheel. The high-pressure turbine casing accommodates also a cruising element, and the low-pressure turbine an astern turbine. Front and back elevations of the port turbines and gears are represented to a larger scale in Figs. 5 and 6, page 473. The manœuvring gear is well shown in Fig. 5.

Longitudinal sections through the two casings are reproduced in Figs. 7 and 8, Plate XXVI. From the former it will be seen that the cruising element fitted at the forward end of the casing consists of one velocity-compounded wheel followed by a simple impulse wheel. The steam, after passing this wheel, escapes through guide blades provided at the bottom of the casing as indicated, and acts on the first wheel of the main turbine. This main turbine has, it will be seen, four wheels, of which the first operates with partial admission, the steam supply for the other three wheels extending round the whole circumference.

When cruising, the steam is admitted to the first wheel of the main turbine along an arc near the bottom of the turbine casing, whilst at full power, the valve shown by which steam is supplied to the cruising turbine is closed, and steam is admitted direct to the first wheel of the main turbine through the guide blades shown near the top of the casing.

In the low-pressure turbine, Fig. 8, provision is made for admitting steam exhausted from the auxiliaries. At cruising speeds, however, this steam from auxiliaries is let into the high-pressure turbine through a branch not shown in the figure. The wheels of both high and low-pressure turbines are designed to make 3,600 revolutions per minute at full power. The maximum peripheral speed is 180 m. per second. The astern turbine is to be seen on the left of Fig. 8. It consists of one velocity-compounded wheel with two rows of blading followed by a simple impulse wheel. It can, as stated, develop 4,400 h.p. when running at 250 r.p.m. Glands, bearings and lubricating arrangements are of the usual type. The glands have spring-mounted carbon packings. The diaphragm packings are of the labyrinth type. One is shown to a slightly enlarged scale in Fig. 9. The ring carrying the packing fins is in sections, held together by springs, and has thus a certain degree of flexibility, being able to yield a little in case the shaft whips. Shoulders prevent the rings closing in on the shaft beyond a fixed limit, the arrangement being, it will be seen, a modification of the type of diaphragm packing introduced by the British Thomson-Houston Company.

The cruising turbine is used for speeds up to 16 knots. Beyond this limit it is cut out of action, and revolves idly in the steam which leaks into its casing through the lower guide blades in the diaphragm separating the two turbines. As the friction work done on the relatively small amount of steam thus entrapped may be considerable, provision is made for letting in a small supply of saturated steam into the cruising turbine casing, so as to keep the temperature down and lessen the risk of distortion.

The blades are of the usual de Laval type, the material being Monel metal. They are not only very securely held, but can at need be very easily removed individually and replaced.

The connection between the turbine and pinion shafting is such as to provide for a certain amount of axial play.

The gears and their casing are represented in Figs. 10 to 15, Plate XXVII. The usual double helical type of gear has been adopted, and the pinions are rigidly mounted. The pitch line speed at full power is 35 m. per second. The propeller thrust is taken on a bearing of the Michel type, the remarkable qualities of which have been confirmed by independent tests made at the works of the builders, in the course of which loads of over 1½ tons per square inch have been carried without trouble. In the present case, however, the designed load on the blocks is 30 kg. per square centimetre (430 lb. per square inch). The main frame of the gear casing is a steel casting, but those parts of it which merely serve to retain oil and keep out dirt are of sheet metal.

Considerable care has been taken in designing the valve arrangements so as to secure effective interlocking. As best seen in Fig. 6, there are three sets of valves above the high-pressure casing, and two above the low-pressure casing. One of the three valves on the high-pressure casing acts as a stop and governor valve, closing down automatically whenever either of the emergency governors shown at the forward ends of the turbine shafts comes into action. These trip a trigger which, when released, opens a valve on the oil supply pipe, destroying the pressure here. A spring-loaded piston, on the release of this pressure, then closes down the stop valve. Of the other two valves, one is used at full power, whilst the other admits steam to the cruising element. The two are operated by cams on the same shaft, so arranged that when one valve is open the other is necessarily shut. Of the two valves shown on the low-pressure casing one admits boiler steam direct to the reverse turbine, and the other controls the supply of steam from the auxiliaries. Safety valves are provided at the exhaust end of the high-pressure turbine and at the admission end of the low-pressure turbine. When the astern turbine is in use the auxiliary steam is passed direct to the condenser.

The oil supply is normally provided by a gear pump driven from the shaft of the circulating pump, but as a stand-by a direct-acting steam-driven plunger pump is also provided. The usual filters and coolers for the oil are, of course, installed.

The condensers being at a higher level than the turbines, float-actuated valves are fitted to secure effective drainage.

The trials of the boats proved very successful, a maximum speed of 35 knots being obtained ahead and 22 knots astern. On reversal from full speed ahead the vessel was stopped in 38 seconds, the distance covered being 150 m.

The new boats have exactly the same boiler plant as their predecessors, so that a comparison between these craft is of especial interest. Some figures are given below:—

——	"Vale" Reciprocating Engines.	"Hugin" Direct-Coupled Turbines.	"Wrangel" and "Wachtmeister" Geared Turbines.
S.H.P.	7,050	9,500	11,000
Revolutions per min.	386	800	450
Speed at full power, knots ..	29·4	30·0	34·0
Steam consumption per S.H.P. per hour at full power, kg. ..	8·80	6·0	5·20
Propeller efficiency, per cent.	64	50	61
Steam consumption per effective H.P. per hour, kg. ..	14·84	14·10	10·0
Coal consumption per effective H.P. per hour, kg.	2·18	2.07	1·47

At cruising speeds the figures are as follows:—

——	Reciprocator.	Direct-Coupled Turbines.	Geared Turbines.
S.H.P.	700	950	1,000
Per cent. of full power ..	9·93	10·00	9·09
Net steam per S.H.P. hour, kg.	10·71	11·8	7·7
Propeller efficiency, per cent.	70	61	67
Coal per effective H.P. hour, kg.	1·76	2.56	1·53
Total machinery weight per S.H.P., kg.	23.48	17.66	15.71
Engine room weights per S.H.P., kg.	16.08	15.75	11·52

In the trials the Vale (with reciprocating engines) displaced 350 tons, the displacement of the Hugin was 380 tons, and of the Wrangel 430 tons.

Some further trials of this latter boat are to be made, since the propellers were ordinary castings, the machined propellers ordered from England not being delivered owing to the war. Moreover, the trials were made in water only 28 m. to 37 m. deep, and it is desired to repeat them in deep water, since, as is well known, the relation between power and speed is greatly affected by depth of water. In the case of the Wrangel's trials the shallowness of the water had the effect of increasing the resistance at speeds of from 27 knots to 30 knots, and diminishing it for still higher speeds. From calculation it had been anticipated that 11,000 h.p. would be developed at 450 r.p.m., giving a speed of 34 knots. The actual speed attained with 11,000 shaft horse-power and 450 r.p.m. was 33·26 knots the discrepancy is attributed to the indifferent quality of the propellers and to the displacement being rather greater than estimated, viz., 455 tons instead of 415 tons.

The maximum power developed was 13,000 shaft horse-power at 480 r.p.m. The speed was 34·8 knots on a displacement of 445 tons. The full load steam consumption as guaranteed was 5·2 kg. per shaft horse-power, and the actual figure was 5·13 kg. Including steam for auxiliaries the guarantee per shaft horse-power hour of the turbines was 6·10 kg., and the actual figure was 5·79 kg.

At cruising speed the makers guaranteed a steam consumption (turbines only) of 7·7 kg. per shaft horse-power hour, as against the actual figure recorded of 6·67 kg. The total steam consumption at cruising speeds was, however, 11·38 kg. per turbine shaft horse-power in place of an anticipated figure of 9·2 kg. The discrepancy arose from the unexpectedly high steam consumption of the auxiliaries, which amounted to 4,692 kg. per hour instead of 1,500 kg. as expected. This was due in the main to the fact that the air pumps,

GEARED TURBINES IN THE SWEDISH NAVY TORPEDO-BOAT DESTROYER "WRANGEL."

CONSTRUCTED BY THE DE LAVAL STEAM TURBINE COMPANY, STOCKHOLM.

Fig. 1.

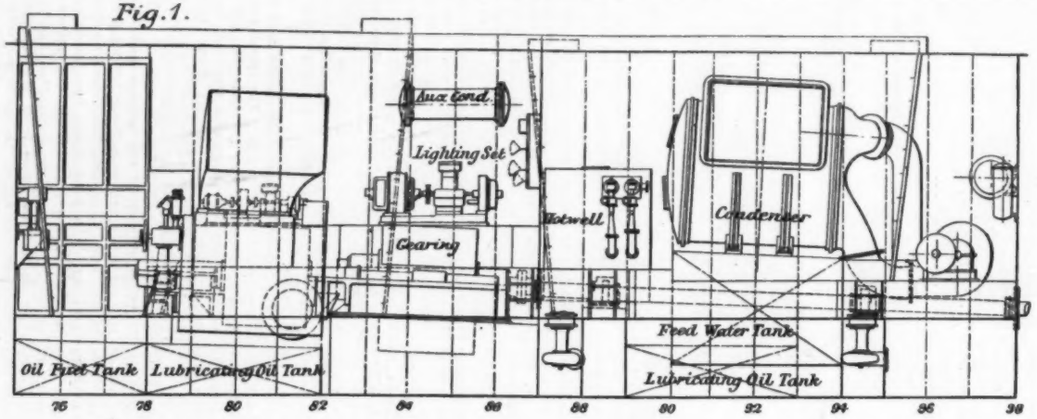
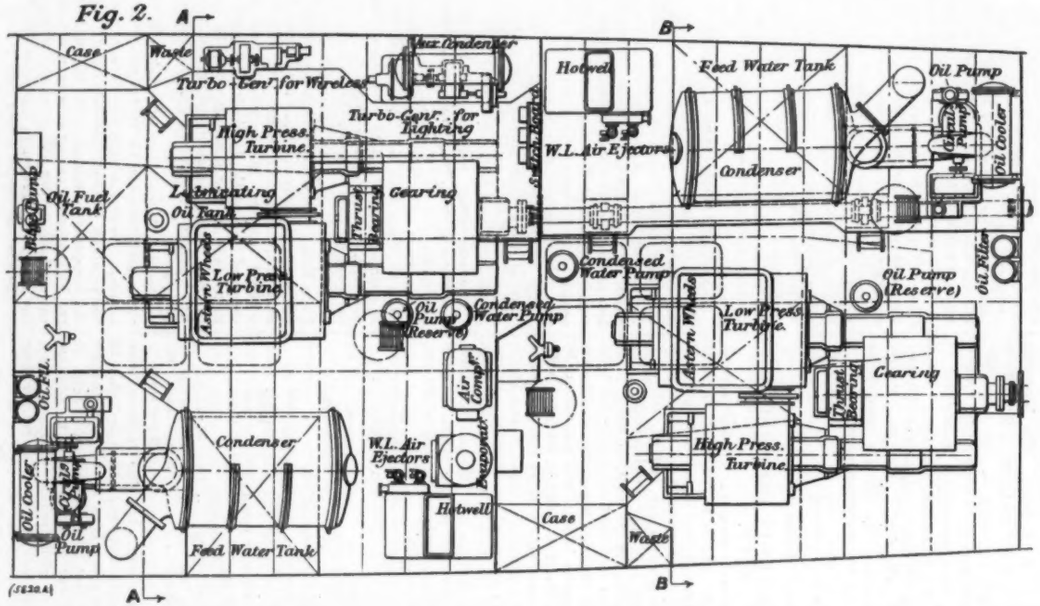


Fig. 2.



(5230 A)

Fig. 3. SECTION B-B. (FRAME 90)

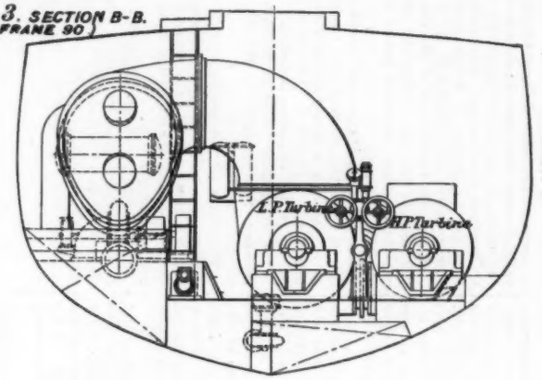
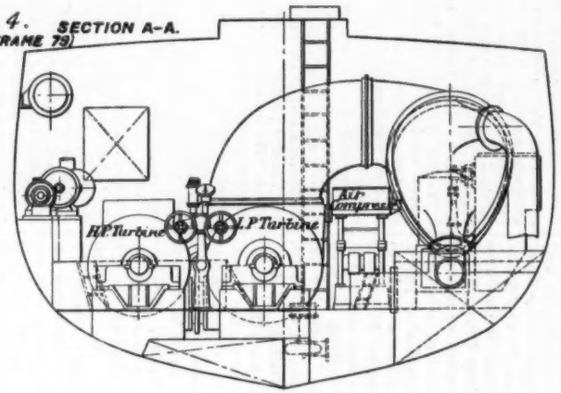


Fig. 4. SECTION A-A. (FRAME 79)



which were of the rotary type, took practically the same amount of steam as at full power. As the steam from these pumps was passed into the turbines the latter benefited, however, by a substantially larger amount of auxiliary steam than had been anticipated. The coal consumption figures, though given, are not fairly comparable since much worse coal had to be employed on the Wrangel's trials than was used on the tests of her predecessors.

The power developed astern was 3,110 shaft horse-power in place of the 4,400 shaft horse-power specified. This arose from a change in the design made during the progress of the work, owing to which the steam supply to the astern turbine was considerably wire-drawn. The speed attained, however, was 20·2 knots the revolutions being 286 per minute.

As already mentioned, the boiler plant is exactly the same in the Wrangel as in the previous boats. It is not a little noteworthy that in the new vessels these boilers sufficed to provide steam for 13,000 h.p., as compared with the 8,000 h.p. of the boats with reciprocating engines. Hence, although the displacement is 455 tons instead of 360 tons, a much higher speed was attained with the same consumption of steam.

We supplement the drawings by nine perspective views on Plates XXVIII and XXIX. Fig. 16 shows the low-pressure turbine, having above it the eduction pipe for the exhaust steam to the condenser. Fig. 17 is a view of the forward end of the port set of turbines, the high pressure and cruising turbines in one casing being to the left and the low-pressure ahead and the astern turbine in one casing in the centre, while to the right is seen the condenser. Fig. 18 is a view of the same set of turbines taken from some distance further towards the port side of

GEARED TURBINES IN THE SWEDISH NAVY TORPEDO-BOAT DESTROYER "WRANGEL."

CONSTRUCTED BY THE DE LAVAL STEAM TURBINE COMPANY, STOCKHOLM.

Fig. 5. VIEW LOOKING AFT AT FRAME 89. (PORT SIDE).

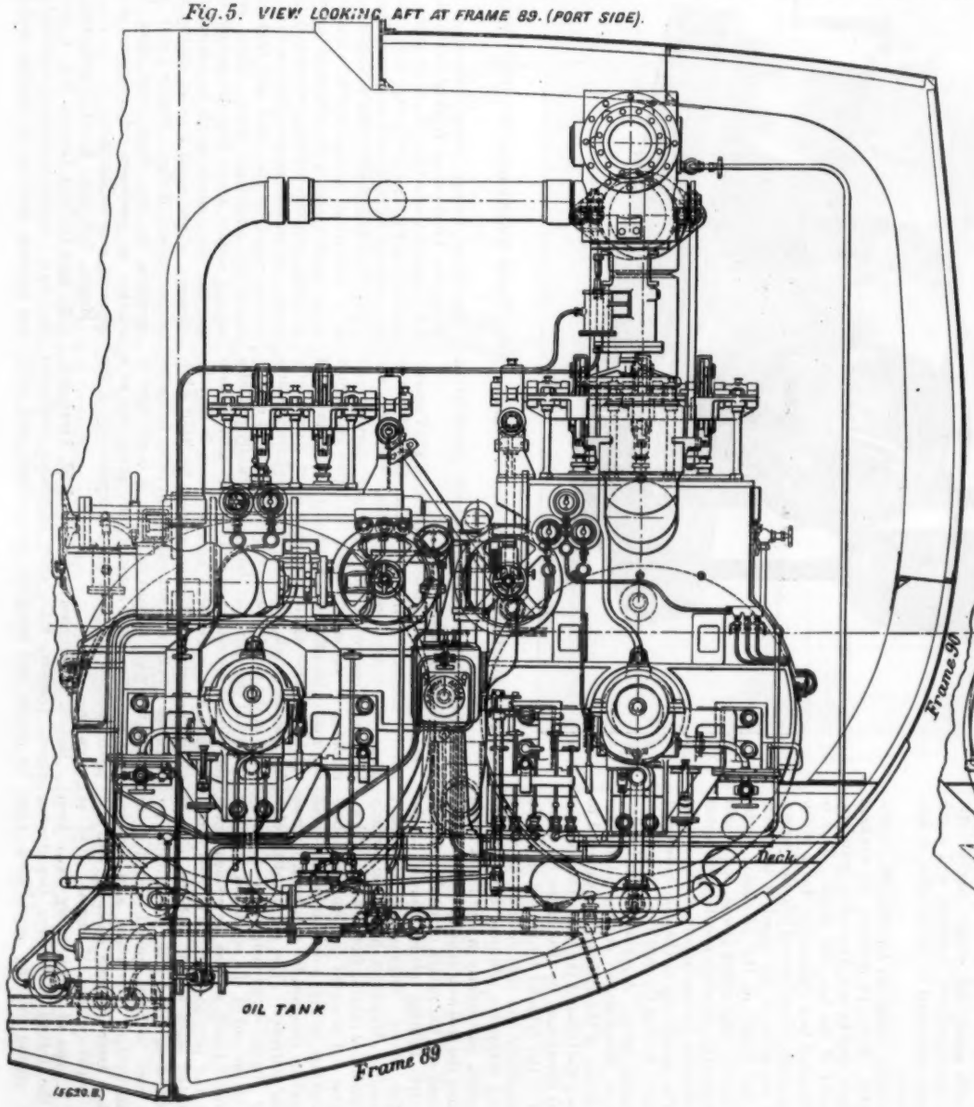
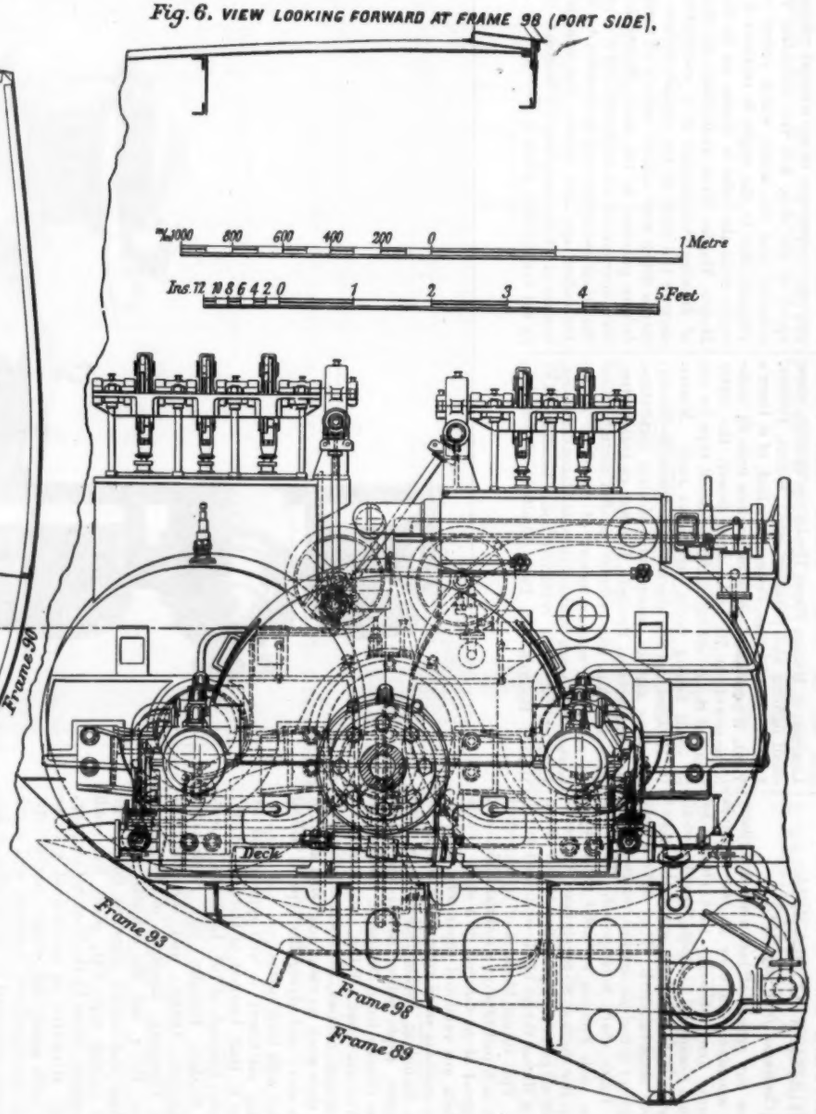


Fig. 6. VIEW LOOKING FORWARD AT FRAME 98 (PORT SIDE).



the ship. Fig. 19, concluding the series on Plate XXVIII, shows the rotor in the lower half of the casing.

On Plate XXIX, Fig. 20 shows the starting platform. This view was taken in the erecting shop of the manufacturers. Note may be taken of the valves above the turbine to secure effective interlocking. Fig. 21 shows clearly the rotor, &c., lifting gear. Fig. 22 is a comprehensive view, taken in the shops from the rear end of one of the sets of turbines, showing the relation of the main gearing, the spindles and turbines. In this view also are seen the three interlocking valves for the cruising and main turbines, and the two corresponding valves for the low pressure and astern turbines. Fig. 23 affords a clear idea of the main gear wheel of one of the sets. Fig. 24, concluding our series, is a general view in the works of the builders, showing various units of the turbines ready for being assembled as a complete installation.

THE SHIPPING AND MACHINERY EXHIBITION AT OLYMPIA.

(*Continued from page 454.*)

Continuing our article of last week describing some of the machinery on view at the Olympia Show, we may first refer to that shown by the Power Plant Company, Limited, West Drayton, Middlesex, who claim to have made the largest gear units ever manufactured. They have a very striking exhibit of a turbine marine reduction gear to transmit 1,250 shaft horse-power. The two turbine shafts, each running at 4,800 revolutions, drive the propeller shaft at 80 revolutions by means of double helical gear, the propeller thrust being taken up by a Michel thrust block contained in the same casing. This thrust block is of an improved type in which each pad tilts on a standard hardened steel ball, instead of on the end of a stud. Parts of such a block are exhibited separately, and the stand further contains some very fine examples of gear cutting, including double helical gears with continuous teeth, triple helical bevels and spurs.

Messrs. the Citroen Gear Company, Limited, of 27, Queen Victoria-street, E.C.4, another well-known firm of gear makers, have some interesting specimens of their work on view, one being a motor car back-axle drive embodying the type of helical gear associated with their name.

Refrigerating machinery is well represented by Messrs. J. and E. Hall, Limited, of Dartford, Kent; John Kirkcaldy, Limited, of 101, Leadenhall-street, E.C.; the Haslam Foundry and Engineering Company, Limited, Derby; and the Lightfoot Refrigeration Company, Limited, of 35, Queen Victoria-street, E.C.; but the exhibits appeared to be all along well-known standard lines. The steam-driven marine type CO_2 plant for small provision chambers, shown by the Haslam Company, is particularly attractive on account of extreme compactness with apparently ample accessibility. All the stands mentioned are, however, well worth a visit by anyone interested in refrigerating or ice-making machinery.

The Lea Recorder Company, Limited, 28, Deansgate, Manchester, show, in addition to working examples of their well-known Vee-notch recorders, a full-sized model of the Lea coal meter. This is an appliance attached to a chain grate stoker which measures the quantity of coal passed into the furnace by combining the effect of the speed of the grate with that of the height of the admission plate. It is in use in several large power plants, and is said to give quite reasonably accurate results when tested against more absolute measurements of the weight of the coal. The integrating mechanism consists of a toothed cylinder having the teeth cut away from one end in a spiral curve. A pinion driven by this cylinder receives, therefore, an amount of motion for every revolution of the cylinder proportional to its position along the latter at the time. The position of the pinion is determined by that of the fire-door, and the speed of the cylinder by that of the chain grate. The simplicity and cheapness of the device render it a very attractive addition to any chain-grate stoker plant, particularly where no facilities exist for weighing the coal as it is used.

Very numerous are the makes of small petrol or oil-driven electric lighting plants shown in the exhibition. The Aster Engineering Company, Limited, of Wembley, Middlesex, have a particularly fine exhibit of such sets ranging from 1 kw. to 25 kw., all direct coupled and mounted on a combined bedplate. We illustrate in Fig. 5 on this page a small Aster plant specially designed for supplying current for arc-welding purposes. The set consists of a single-cylinder engine direct-coupled to a small dynamo, and on the end of the combined bedplate is a skeleton switchboard, so that the whole plant is self-contained and very compact. The completely enclosed iron-clad main switch and the general simplicity of the design render the set suitable for operation by men without special electrical or mechanical knowledge. The stand also contains a direct-coupled Aster-Drysdale pumping set, and a handsome eight-cylinder V engine rated at 110 h.p., of a type of which many have been supplied to the Inland Waterways Department. A two-cycle engine of the semi-Diesel type built to run on heavy fuel oils, is also to be seen on the stand. Messrs. Stuart Turner, Limited, of Market Place, Henley-on-Thames, show small lighting and pumping sets; Messrs. Petters, Limited, and Vickers, Petters, Limited, of 6, Dean's Yard, Westminster, show oil engines from 2½ brake horse-power to 70 brake horse-power, the latter being of the reversing marine crude-oil type for use in small fishing boats and other craft. Messrs. W. H. Allen and Son also show oil-driven machinery, including salvage pumps and electric generators. Messrs. Maclaren Brothers, Limited, of Dumbarton, have a 20-h.p. four-cylinder paraffin marine motor on view, and marine motors of American manufacture are shown by the Evinrude Motor Company, Limited, of 107, Waterloo-road, London, S.E. Messrs. Boulton and Paul, Limited, of Norwich, are also among the exhibitors of small petrol-driven electric-lighting sets.

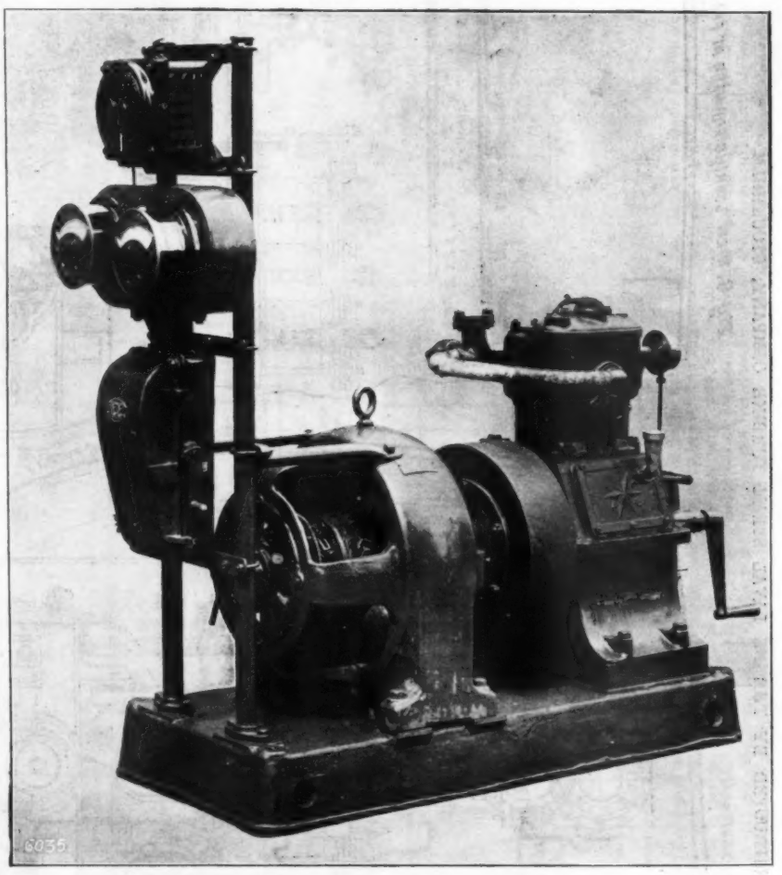


Fig. 5. Oil-Driven Arc-Welding Electric Set; Aster Engineering Co., Ltd., Wembley.

Messrs. R. and A. Lister, Limited, of 47, Victoria-street, London, S.W., show the Lister-Bruston plant for country house installations which has the ingenious feature of the automatic starting and stopping of the engine when the lights are turned on or off. This firm has developed a modification of the type for use as an emergency plant, particularly for marine work. This type immediately starts itself in the event of any failure of the main electric service of the ship, and thus automatically provides the wireless operator and other officers with a source of light and power at a moment when it may be vitally important. The plant stops by itself when the main service is resumed, and in order to ensure that it is always in working order, it is arranged to start and stop itself automatically every day at a predetermined time and quite independently of the operator.

Messrs. H. Hughes and Son, of 59, Fenchurch-street, London, E.C., show numerous compasses for marine and aeroplane use, sextants and other nautical instruments of their manufacture. A hand-sounding gear on the stand shares with the Kelvin gear the convenience of use without reference to the speed of the ship, but the indicating tube is of celluloid and the water which enters under the pressure due to the depth is retained by a small valve until the tube is drawn up to the surface. Messrs. Hughes have undertaken the manufacture of drawing instruments at a reasonable price to capture the trade in the cheaper classes of instruments which were almost entirely of foreign manufacture previous to the war. Numerous cases of their instruments are exhibited, and it is to be hoped that their enterprise will be justified by its results. Binoculars are also shown, the complete manufacture of which, including the lenses, is carried out by the firm at their works in Essex.

The Whirl Rotary Pump Company, Limited, of Marshgate Engineering Works, Stratford, London, E.15, exhibit a new type of rotary pump, which we illustrate in Figs. 6 to 8 on page 475. The design is along the same lines as that of the well-known rotary engine, namely, there is a rotor mounted eccentrically in a cylindrical casing, which, when it revolves, causes an alteration in the volume of spaces bounded by sliding shutters working between itself and the casing. In the present case there are five "slippers" carried round by the rotor and held against the casing by centrifugal force. They have ample bearing surface where they rub against the casing, and the line-contact which is detrimental to the efficiency of the usual type of shutter is avoided by the present design. Pumps are to be seen in operation on the stand, and their behaviour, whether as producers of pressure or vacuum, appeared very satisfactory.

Messrs. Industrial Waste Eliminators, Limited, of 20, High Holborn, London, W.C. 1, are exhibiting the "Iwel" turbine centrifugal combined extracting and washing machine for treating and reclaiming

EXHIBITS AT THE SHIPPING AND ENGINEERING EXHIBITION AT OLYMPIA.

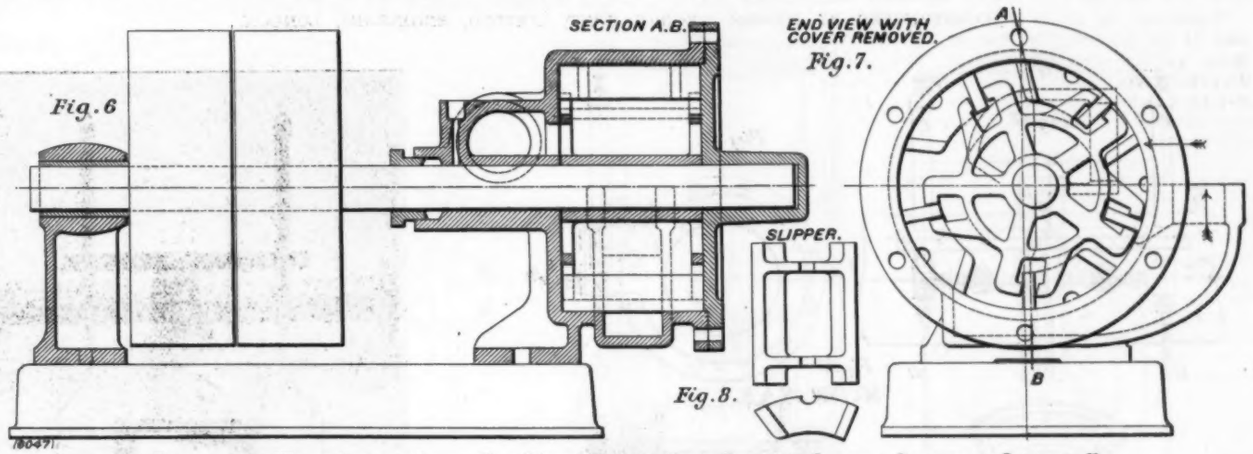
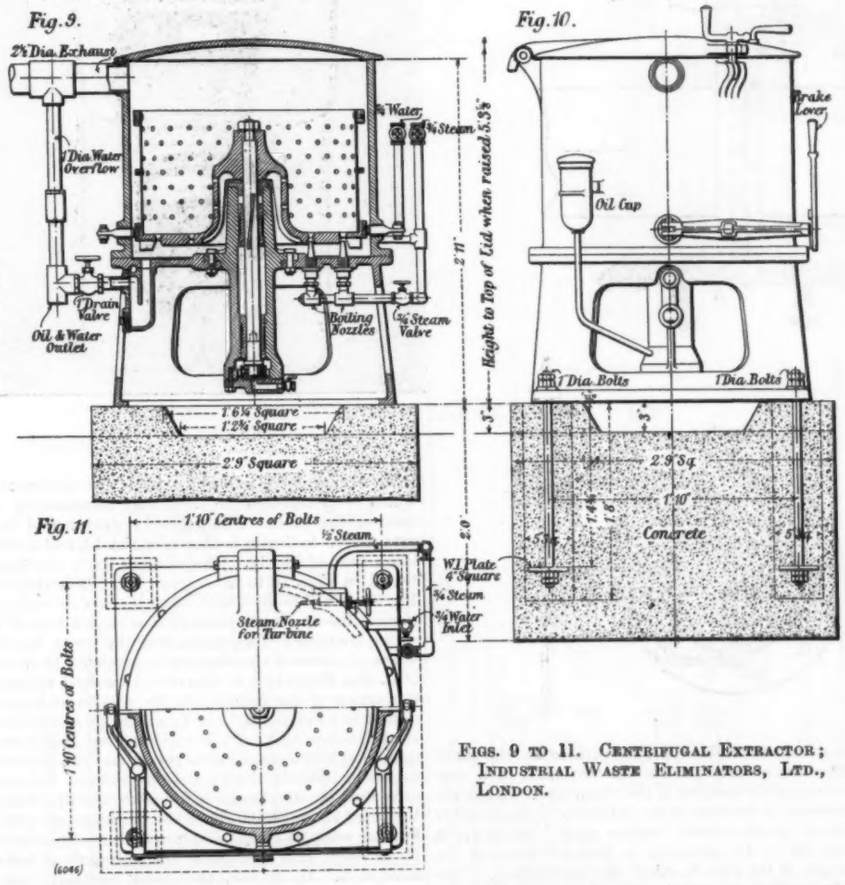


FIG. 6. THE WHIRL ROTARY PUMP; THE WHIRL ROTARY PUMP COMPANY, LIMITED, STRATFORD, LONDON, E.



FIGS. 9 TO 11. CENTRIFUGAL EXTRACTOR; INDUSTRIAL WASTE ELIMINATORS, LTD., LONDON.

oily cotton waste, sponge cloths, filter bags, and innumerable other kinds of dirty or greasy material. This is a new machine, which combines the functions of an oil extractor, a washing machine, and a water or hydro-extractor. Its construction will be clear by reference to Figs. 9, 10 and 11, annexed. A cast-iron cylindrical casing is bolted to a base having a central column in which runs a vertical shaft mounted on a ball bearing. The upper end of the shaft carries a perforated steel cage on the base of which are mounted turbine blades. Removable wire baskets, which fit into the steel cage, are provided for holding the material to be heated. Steam and water connections are fitted as shown in Fig. 9. For oil extraction the basket containing the greasy material is put into the cage and the oil outlet opened. Steam is turned on to the turbine nozzle, and the heat, together with the centrifugal action, separate the oil, which runs away through its outlet. For washing the de-oiled material, the oil and water outlets are closed, water is run in, and the cage slowly rotated by a small steam jet. At the same time steam is turned on to the boiling nozzles and rising through holes in the bottom of the revolving cage, agitates the material and boils the water. When washing is finished the water and oil are run off through their respective outlets. Drying is performed similarly to oil extracting, except that the water outlet is opened and the oil outlet closed. The machine works with any steam pressure from 30 lb. upwards, and is recommended for use in ships, power stations, oil mills, &c. Fatty meat scraps and bones can also be dealt with.

Messrs. Scholey & Co., Limited, of 56, Victoria Street, London, S.W. 1, exhibit an example of Cope's automatic boiler feed-water regulator, of which they are the sole British manufacturers. The apparatus comprises a thermostat in the form of a long inclined tube made of an alloy having a high coefficient of expansion. This tube is connected at its upper end to the steam space, and at its lower end to the water space, of the boiler, and it is placed so that its centre part is at the same level as the surface of the water in the boiler under normal working conditions. In this condition half of the tube will be filled with steam at the temperature of the boiler, and half with water, the temperature of which will be but little above that of the room. Any change of level of the water in the boiler will, of course, be followed by a fall or rise of the water in the inclined tube, thus giving the hot steam access to more or less of its surface. One end of the tube is attached to the short arm of a bell-crank lever, the long arm of which is connected to a balanced valve in the feed line, and as the other end of the tube is fixed the longitudinal expansion of the latter opens or closes the valve. The effect of this is that when the load on the boiler increases and the water level falls, the tube expands, opens the valve more, and admits a greater quantity of feed water to the boiler; the opposite action, of course, takes place if the load on the boiler lessens. The feed is thus continuous and proportional to the load, but it should be noted that the level in the boiler will be higher at light loads than at heavy loads. This is advantageous in that the extra water present in the boiler at light load acts as a reserve of heat which is utilised when the load increases. With rapidly fluctuating loads the effect of the regulator is rather different. A sudden increase of load, being accompanied by a drop in pressure, causes the omission of a large number of steam bubbles, and thus the water level rises. The supply of feed is consequently reduced by the regulator, so that the increased demand is supplied by the heat stored in the water in the boiler, and the cooler feed is not added until the water level has fallen below its previous level. During a short period of subnormal load, additional feed is added, so that heat is stored ready for an increased demand. In this way fluctuations in the furnace temperature following sudden changes in the load are greatly reduced. The design and construction of the apparatus appears to be sound, and there are no delicate parts which are likely to give trouble. We understand that upwards of 2,500 boilers have been fitted with these regulators. Examples of "Kutmore" portable electric drills are also shown at Messrs. Scholey's stand.

The Kent steam meter, exhibited by Messrs. Geo. Kent, Limited, of 199, High Holborn, London, W.C. 1, is well worth inspection by engineers who

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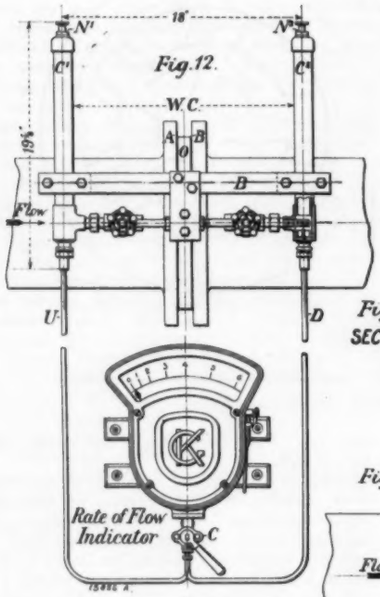

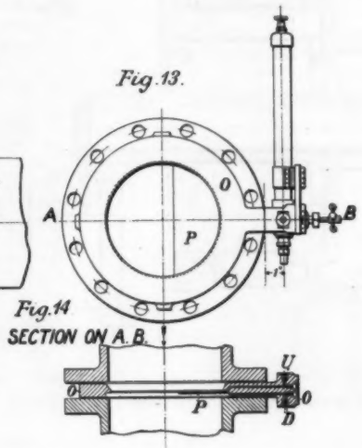

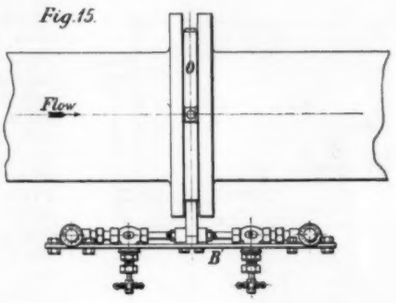

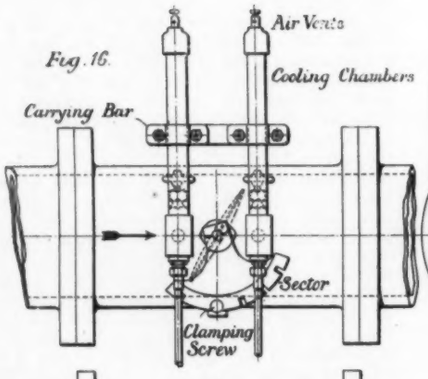

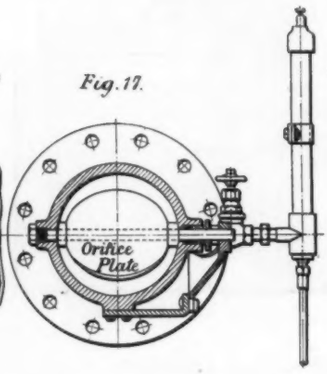

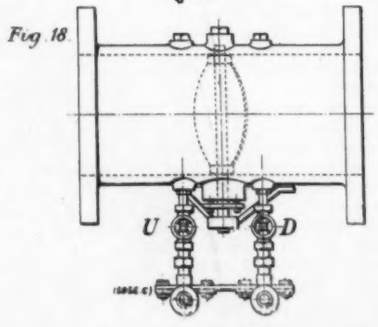

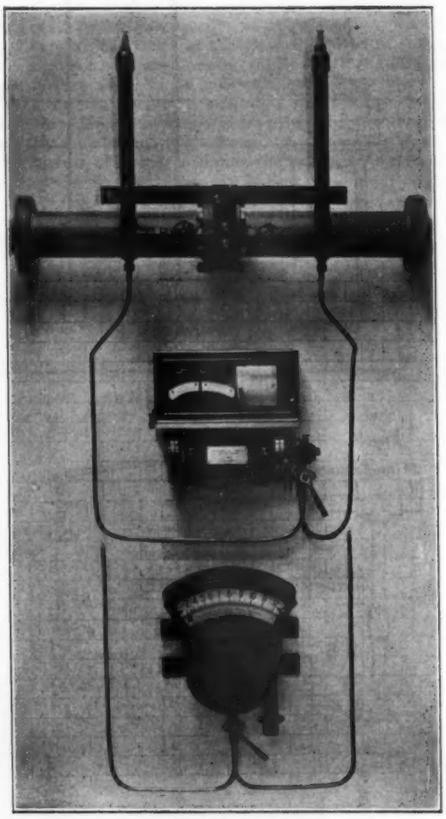

Fig. 19.

are interested in the measurements of steam. The instrument is constructed either as a simple indicator to show the rate of flow at any instant, or as a graphic recorder which shows on a chart the variation in the rate of flow. The latter type is also furnished with an integrating device to give in figures the number of pounds of steam which have passed during any period. The mechanism of the instrument, whatever the type, is operated by the slight difference of pressure on the two sides of a constricting plate inserted in the steam pipe. When the variation of the flow of the steam to be measured is not too great a fixed "orifice plate," as shown in Figs. 12 to 15, annexed, is inserted between the flanges of the pipe to effect the constriction. This only involves separating the flanges by 1 in. or 1½ in., according to the size of the pipe. From each side of the plate P pressure ports are drilled terminating in connections U and D, Fig. 14. Pipes from these connections run down to the meter, and terminate upwards in cooling chambers C, which are provided with air-vents N.

Should the range of flow be greater than could be efficiently dealt with by one orifice plate, the device shown in Figs. 16 to 18 is used to avoid the necessity of changing the plates. It consists essentially of a short length of pipe containing a carefully constructed butterfly valve which may be locked in various positions by means of an external sector. The overall range of accurate measurement which can be obtained by the use of this device goes down to one-thirtieth of the maximum flow, as compared with a range down to one-quarter of the maximum, which is all that can be accurately measured by a fixed orifice plate. The general appearance of the rate of flow indicator is shown in Fig. 12, and in the lower part of Fig 19. The working parts are illustrated in Figs. 20 to 23, on page 477. Referring to Fig. 21, it will be seen that when the control cock is turned, the up-stream pressure is admitted behind a spring-controlled diaphragm, and the lower down-stream pressure is simultaneously admitted in front of it. The diaphragm is thus forced forward against the action of the springs and its motion is transmitted to a bell-crank lever L, which, by means of a vertical connecting rod and another lever, causes the spindle of the instrument to rotate and the pointer to move. Should the up-stream pressure become excessive, the diaphragm is forced over until a valve V carried at its centre closes the down-stream port. Further pressure on the diaphragm causes the valve W to open, thus equalising the pressure on both sides of it. If, on the other hand, by faulty connection or otherwise the pressure on the back of the diaphragm becomes excessive, the latter bends until it is supported by the back of the instrument, and no harm comes to it.

The spindle of the instrument is in two quite separate parts, the part actuated by the diaphragm, as already described, carries at its outer end a strong permanent magnet. This acts upon an iron armature mounted on the other portion of the spindle which carries the pointer, and drags it round by the magnetic pull. By using this device a water-tight gland for the spindle to pass through is rendered unnecessary. The end of the spindle with its armature are shown in Fig. 23.

Turning now to the recording instruments, the simplest types of these in which there is no automatic correction of the readings for any variation in

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Fig. 20

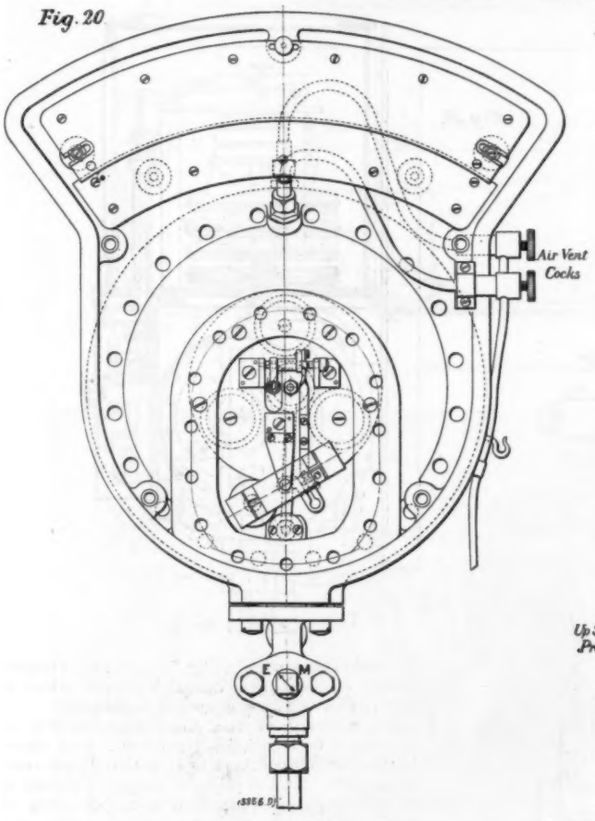


Fig. 21.

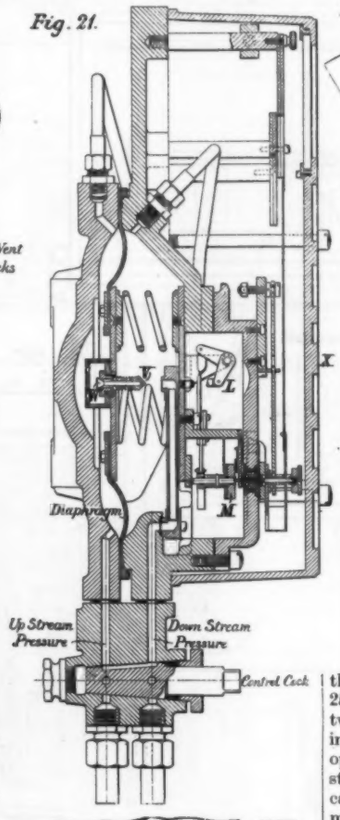


Fig. 22.

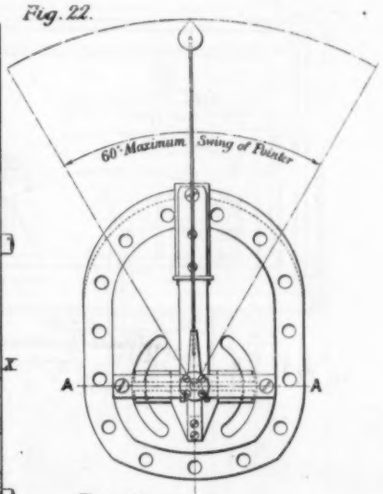


Fig. 23.

SECTION ON LINE A.A.

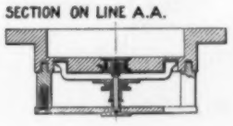


Fig. 24.

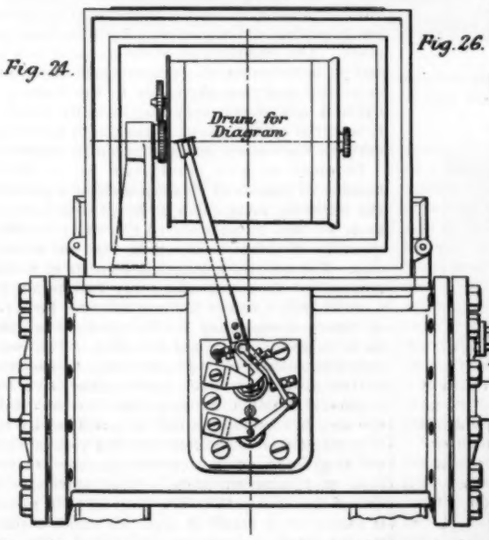


Fig. 26.

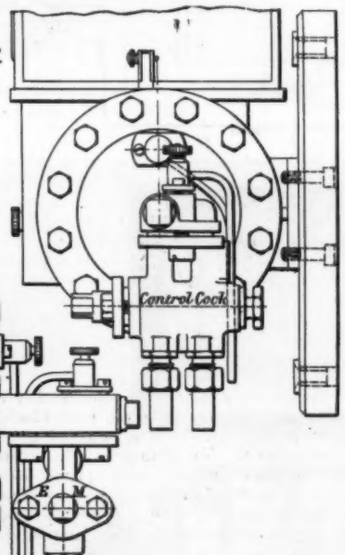
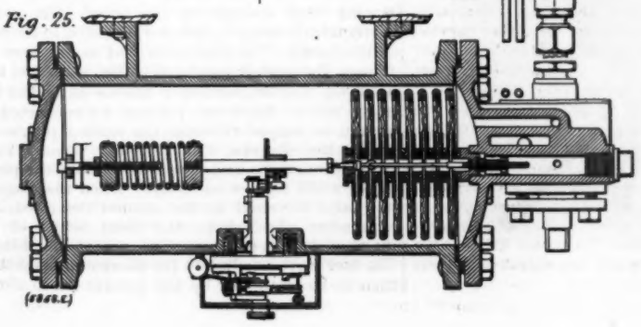


Fig. 25.



the pressure of the steam, is illustrated in Figs. 24, 25 and 26 annexed. The pressure pipes from the two sides of the orifice plate are connected to the instrument as before through a control cock which opens and closes them simultaneously. The up-stream pressure is admitted to the interior of the casing and acts on the outside of a series of flexible metallic diaphragms, similar to those in an aneroid barometer. The lower down-stream pressure is on the inside of the diaphragms, and the tendency of the latter to close up under the pressure difference is resisted by a spiral spring. The arrangement is illustrated in Fig. 25. The motion of the coupling rod connecting the diaphragms with the spring is transmitted to a horizontal spindle which passes through a packed gland to the outside of the casing and actuates the pointer, carrying the recording pen. The general appearance of this instrument is shown in Fig. 19.

Should the instrument be required to give an accurate record of the quantity of steam passing regardless of considerable variations in the steam pressure, and therefore of its density, the type of meter illustrated in Figs. 27, 28 and 29, on page 478 is employed. In addition to the recording drum, this instrument contains two scales, each with its own pointer. The left-hand scale reads the pressure of the steam being metered, while the right-hand scale shows the differential pressure across the orifice. In Fig. 28 and at the left-hand side of Fig. 27 can be seen diaphragms on a vertical axis, surmounted by a strong helical spring. The working steam pressure tends to expand these diaphragms against the act on of the spring, and their motion is transmitted by means of the vertical rod A to the pointer B. There is another set of diaphragms in the body of the meter similar to those shown in Fig. 25, whose motion under the influence of the pressure drop across the orifice plate, actuates the spindle C, and by means of a crank arm and link, causes the rotation of the curved arm D, and the consequent motion of the pointer E. The vertical movement of the rod A, acting through the link F, depresses the connecting rod G and consequently influences the amount of movement of the recording pointer H. The latter thus has a motion affected jointly by the pressure drop across the orifice, and the absolute pressure of the steam, so that it records with great exactness the true energy in the flow of steam along the pipe at any time. The mechanism which is shown at

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Fig. 27.

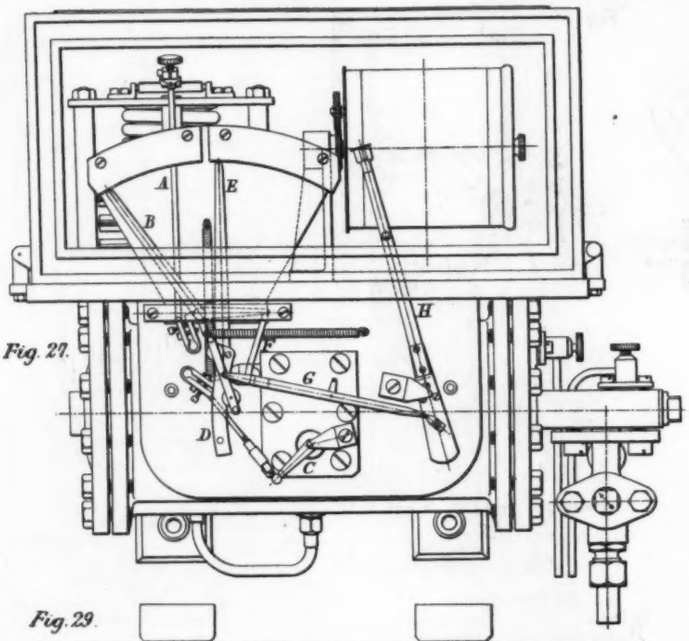


Fig. 28.

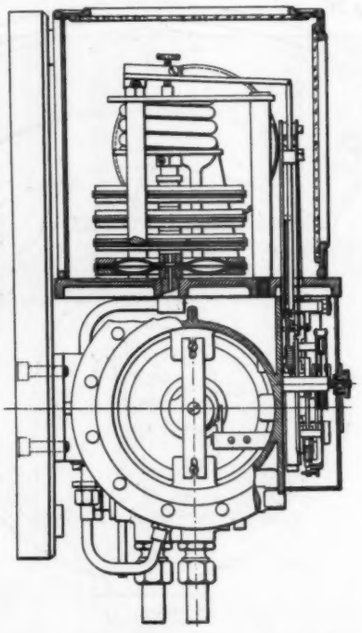
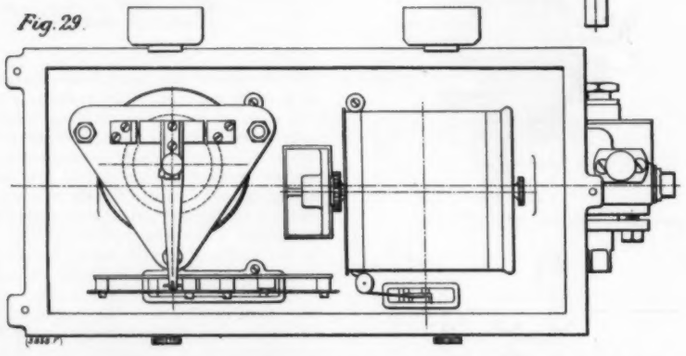


Fig. 29.



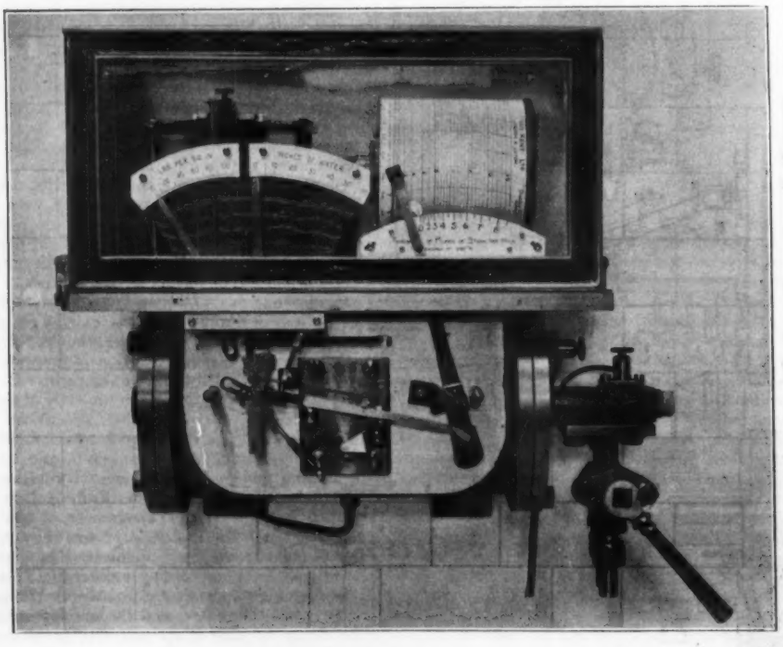


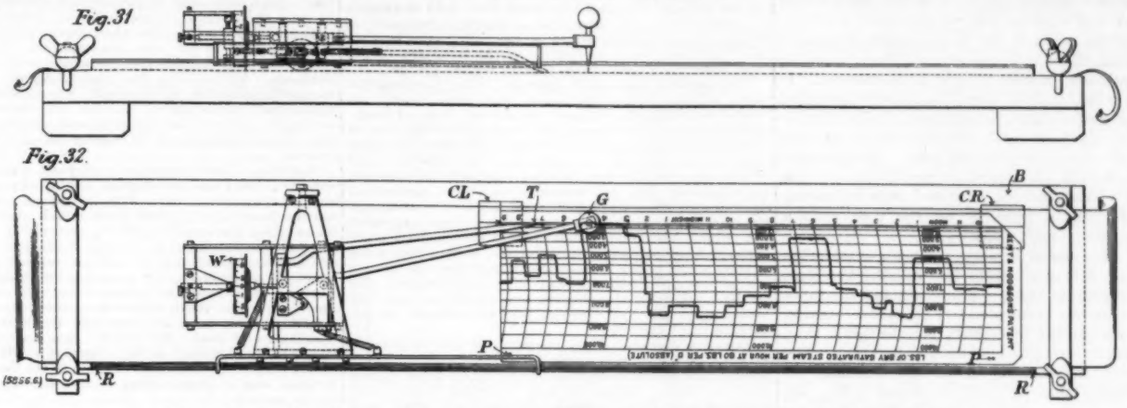
Fig. 30.

the front of the meters in Figs. 24 and 27 is, of course, entirely enclosed by a dust-tight shield, which is easily removable for purposes of inspection.

The accuracy of the Kent steam meters is guaranteed to be within 2 per cent. from three-quarters to full load, and to be within 2½ per cent. at half load. This is probably as great accuracy as can be commercially attained in the metering of steam at the present time, and compares not unfavourably with the working results of apparatus for measuring either coal or water in a steam power plant. The sensitiveness of the meter is very great, and we have known of a case in which the extra load on a city pumping plant due to the opening of a hydrant was shown very emphatically every time it occurred by the record of the steam meter placed between the boilers and the pumping engines.

In order to give information as to the total number of pounds of steam passed in a given time, the recording meters can be fitted with integrating gear, so that in addition to the chart record, the quantity of steam used can be read off a counter-dial. The counter-mechanism consists of a spindle rotated by clockwork once every two minutes, and a clutch which drives the number-dials for a period of time corresponding to the quantity which has to be added to the counter-reading. The counter-record is claimed to be acurate down to one-seventh of the maximum flow. As an alternative to the numerical counter, or as a check on its readings, the area of the diagram can be measured by means of a planimeter. The fact that the vertical scale of the diagram is not an even one necessitates a special type of planimeter, such as that shown in Figs. 31 and 32, on page 479. The diagram to be measured is placed on a board B (Fig. 32) under a piece of tracing cloth clamped to the board. The planimeter travels along a guide rail RR fixed to the edge of the board. The planimeter dial having been set to zero, the guiding pointer G is then moved so that a tracing pointer, marked T follows along the line of the chart. These two pointers are connected by a cam, so shaped to cause the tracing pointer to follow the diagram. The guiding pointer must move through the angle required to make the planimeter wheel register correctly. When the diagram has been traversed in the manner described, the planimeter wheel shows the mean height of the diagram as a percentage of the maximum height. The flow corresponding to the maximum height has then to be multiplied by this percentage to obtain

EXHIBITS AT THE SHIPPING AND ENGINEERING EXHIBITION AT OLYMPIA.



Figs. 31 and 32. Special Planimeter for Measuring Diagrams of Kent's Steam Meter.

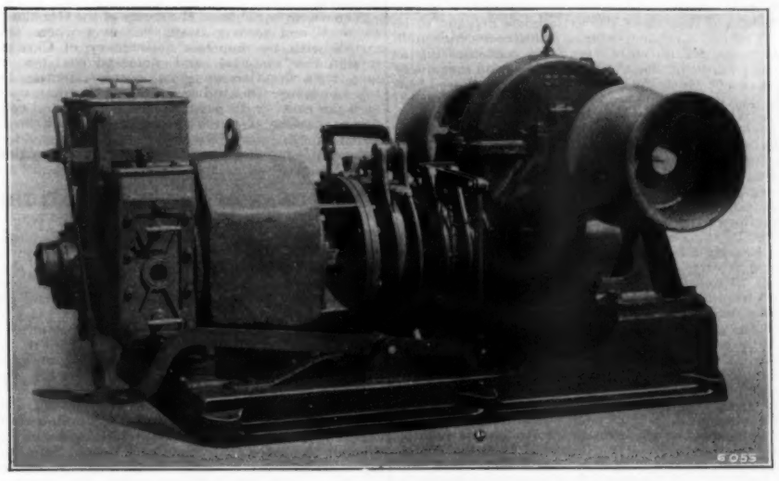
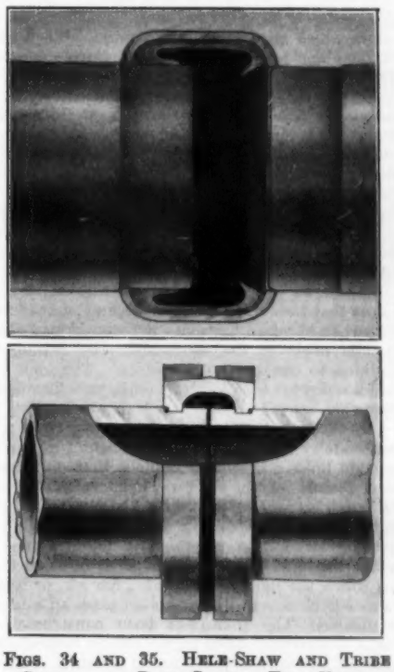


Fig. 33. Electrically-Driven Winch; Messrs. Laurence Scott and Co., Ltd., Norwich, and Messrs. John H. Wilson and Co., Ltd., Birkenhead.



Figs. 34 and 35. Hele-Shaw and Tribe System of Pipe Joint; The Victory Pipe Joint Company, London.

the average rate of flow for the period covered by the diagram.

A good display of some of their special lines of work is made by Messrs. Laurence Scott & Co., Limited, of Norwich. These are in the nature of ship material and thus are in keeping with the supposed general character of the exhibition. The main exhibits are two, an electrically driven deck winch and an electrical steering gear. The winch is arranged with a load and is to be seen in operation. Its mechanical part was made by Messrs. John H. Wilson & Co., Limited, of Birkenhead, the well-known crane and steam winch builders. It is of the worm-driven type. An illustration of one of Messrs. Laurence Scott's whipping-drum winches, with the mechanical parts also by Messrs. John H. Wilson and Co., is shown in Fig. 33. The winch shown at Olympia is built generally on the same lines as this, but is of larger type and has a main lifting barrel.

The conditions which a ship deck winch have to meet are very onerous and the standard type of steam winch is a robust and simple appliance which has been developed to a point at which it is comparatively indifferent to ill-usage. The construction of an electric winch which satisfactorily can stand up to these same conditions is by no means a simple matter, and the electrical features of the models which have been produced are of considerable interest. Messrs. Laurence Scott's electric winch is operated by a master controller fixed in a convenient position on the winch itself. This master controller operates a contactor controller which is placed under shelter below deck. The speed of cutting out resistance cannot be increased to a dangerous extent by any manipulation of the master controller, nor can the fuse be deliberately blown by manipulating it. This renders the winch safe in the hands of the roughest or most ignorant labour. In the case of stalling through overload, which may easily occur even with a pure cargo winch, owing to the lifting hook catching in a hatch coaming, a steam winch simply pulls up. The counterpart of this property of a steam winch is provided in the electric winch by a slipping clutch. In conjunction with this clutch a centrifugal brake is fitted which comes into action to prevent excessive speed of the armature when an extra heavy load is being lowered. The brake is purely a mechanical one.

The remaining important electrical feature of the winch is the Scott-Bentley "load-discriminator" gear. The object of this gear is to increase the lifting speeds for light loads. The ordinary characteristic of a series-wound motor gives high speeds at light loads and slow speeds at heavy, but the relation between load and speed is such that between full and half load the speed rises but little, there being however a rapid rise in speed as the load falls to less than one-third full load. These conditions are not particularly suitable for a cargo winch, as to a considerable extent such appliances operate round about half load. The Scott-Bentley gear maintains the horse-power exerted approximately constant and greatly increases the half-load speed as compared with an ordinary series arrangement, making it about double. During starting-up and with heavy loads the load-discriminator does not come into action and the whole series current goes round the field magnets in the usual way. When, however, the current falls owing to a lighter load being lifted it diverts some of the current out of the series winding, and the speed rises. The discriminator is part of the contactor gear. It will be understood that it is not an overload device. In a sense it anticipates overload. Normally it prevents the series being diverted, *i.e.*, it keeps the diverter resistance circuit open if the torque on the armature is above a predetermined amount. If the series were diverted there would be an overload, but such diversion does not take place unless the torque is such that the diverting of the series current does not cause an overload.

A novel exhibit is made by Messrs. the Victory Pipe Joint Company, of 64, Victoria-street, London, S.W. 1. This consists of examples of the Hele-Shaw and Tribe system of jointing pipes. The system in two of its forms of application is illustrated in Figs. 34 and 35 on page 479. The whole arrangement is very simple and will almost be understood from the figures without description. The essential feature is a flexible ring of U section with the lips curved inward and the edges fined. Referring to Fig. 34, one of these rings is shown in position on the left-hand pipe and is ready to receive the right-

hand pipe which is shown separately. The curving inward of the lips of the ring is clearly shown on the right-hand side, the lip on the left having been forced inward by the pushing of the pipe into position. The inside diameter of the ring is made somewhat smaller than the outside diameter of the pipe which it is to embrace, so that a tight fit is ensured. It will be clear that with the joint completely assembled internal pressure in the pipe will hold the lips tightly down on to the pipe ends, and that the higher the pressure the tighter will be the joint. The arrangement is, in fact, an ingenious application of the hydraulic U leather. It is stated that by having the flexible ring a tight fit on the pipe ends a vacuum is successfully held.

In Fig. 34 a metal housing is shown outside the flexible ring, but apart from this housing the joint consists of nothing but t e joint ring and the pipes which are to be connected. The metal housing forms a mechanical protection for the joint ring, but also clearly strengthens it against bursting. The flexible ring is moulded inside the housing. It will be evident that the joint, as shown in Fig. 34, gives no protection against longitudinal displacement of the pipes. It is only suitable for application to fixed pipes, such as those buried in the ground. Expansion is provided for, since the ends of the two pipes which are joined do not meet. When longitudinal displacement has to be provided against the form of joint shown in Fig 35 is employed. In this case the flexible ring is embraced by a split housing which engages in grooves cut in the pipe ends. This split housing is tapered both ways on the outside and is held in position by two rings fitting on the tapers as shown. These rings take the bursting stress. Expansion is again provided for in this joint by the ends of the pipes being kept separate and the grooves in which the housing rests being made wide enough to allow of some longitudinal movement of the pipes.

It will be clear from the construction of these joints that they have a certain amount of flexibility, but when absolute flexibility is required a modification is made in the construction by fitting ball ends on to the pipes to be joined. The joint ring and housing are then formed to suit, the construction following almost exactly that shown in Fig. 35. In another form the arrangement of Fig. 34 is more nearly followed and the joint is held together by outside links. It will be evident that one important feature of the Victory joint is that it contains few parts and requires no special tools to be put together. It can, in fact, be assembled with nothing more than a hammer. The material of which the joint ring is made depends on the service for which the joint is intended. For air, or water, rubber is used, and in some other cases an asbestos compound. The joint has been constructed to stand pressures of 7,000 lb. per square inch without leakage, and various joints under pressures of up to, we think, 3,000 lb. are to be seen at Olympia. The joint is, we understand, being tested under practical conditions by several important water undertakings.

At the stand of the British Westinghouse Electric & Manufacturing Co., Limited, of Trafford Park, Manchester, are shown a complete high-pressure marine trubine and a low-pressure rotor for a 3,000 h.p. installation. These turbines, which are of the Westinghouse-Rateau type, are of the same type as were designed and constructed for the geared turbine ships Amarna and Assiout, and as we illustrated and described the machinery of these vessels on page 666 of our last volume, we must refer our readers to that article for full particulars. Steam nozzle boxes, one of which is for a 20,000 h.p. turbine, turbine diaphragms and turbine blades of various sizes, showing the process of manufacture, are also shown.

In concluding our notice this week we should say that owing to the railway strike having interfered to a considerable extent with the possibility of visitors from the provinces attending the exhibition, it has been decided to keep it open until Tuesday, October 21 instead of closing it on Friday, the 17th inst. This will, we trust, enable a substantially larger number of engineers to see the display than would otherwise have been possible.

(To be continued.)

THE FUTURE OF GERMANY'S TRADE.

It is stated that 10,000 firms, mostly German, exhibited at the German National Industrial Fair, held in Leipzig in September, and there was a record attendance of about 118,000 people, about 20 per cent. more than in any previous year. According to the secretary of the fair, there were some 7,000 foreign buyers present.

The general impression gathered from conversation with representative exhibitors was that nearly all branches of German industry are on the verge of bankruptcy, due to the shortage of coal and to the loss of export trade which carries with it the inability to purchase much-needed foreign raw materials. In order to assist in forcing a wedge into foreign markets, the German manufacturer has concentrated on new mechanical devices and novelties, which were much in evidence at the fair. Most of the German representatives expressed the opinion that they would recover their export trade through American and neutral buyers, adding that much as they would prefer to re-establish their pre-war trading connection with England, they felt that at present, due to the hostility of the English towards them, they had better concentrate on America and the neutral nations surrounding Germany.

Technical Section.—From the point of view of German export, probably the most important exhibits were those of the technical section, including all types of new machine tools, mechanical and electrical devices and novelties. In this industry, the Germans were in a position to fill orders quickly: in many cases they had considerable stocks on hand, owing to the fact that they had not been short of iron ore and coal during the war to the same extent as industries relying on foreign raw materials, and that there was little home demand to be met. The mechanical engineering industry depends upon foreign trade for its stability; it is concentrating as much as possible on fine mechanical precision machinery and articles in which the raw material and coal used bear a small percentage compared to the value of the finished article. The accuracy of the work done by the machinery exhibited, and the finish of the machines themselves, left nothing to be desired. A notable feature was that every effort had been made to avoid the use of brass. For instance, in lieu of expensive brass grease cups or cheap cast-iron ones, the Germans were using a finely-finished pressed steel article.

The following points summarise the general impressions conveyed by this section: (*a*) Delivery from stock can in most cases be obtained for machine tools. The representative of a large Dresden firm stated that they had in stock 25 to 40 of each type, from the largest to the smallest machine. (*b*) The prices are approximately 200 per cent. to 400 per cent. above the pre-war bases. (*c*) The German firm arranges all the necessary export regulations and shipping, leaving the import side to the importer. Cash must be deposited in the German bank on the receipt of invoice stating that the goods are ready to be despatched, or, in some cases, that they have already been forwarded. (*d*) International banking regulations with England have not yet been re-established in the unoccupied area, although for the last six months a considerable amount of business has been transacted with Holland, Norway, Sweden, Spain and North and South America. (*e*) A very high proportion of the goods sold during the last six months has been for export. (*f*) The chief factor limiting output of heavy machines is coal. (*g*) Much specialised new machinery was shown, and in many cases the Germans are only too willing to sell the covering patents to foreign manufacturers. This fact as to patents appears to be one of the most important brought to light during the whole fair, and expert technical men representing British firms in the various industries would have found much of vital interest to them in this respect. In this connection notice is called to the fact that a fair is being held at Frankfurt-am-Main until the 15th inst., where there are represented a large proportion of the engineering firms referred to above, and thus another opportunity is afforded for British manufacturers to benefit by the careful study of exhibits.

Paper and Paper Manufactures.—There was very little variety in the goods displayed in this section; the only articles available to any useful extent were: (1) Art prints of every conceivable description, comprising all types of pictures, framed and unframed, calendars, post cards, blotting pads, and numerous styles of decorative printing. Excellent colour-work was the chief feature. (2) Writing stationery. This was all of the usual German quality of flat paper. No manilla paper whatsoever was exhibited.

Many of the factories are closed owing to the lack of raw materials, and the larger concerns, which are keeping on the majority of their employees, are working at about one-third of their maximum output. The situation can be summarised by stating that, owing to lack of raw materials, the better grades of paper and stationery cannot be produced and the export and home orders combined for lower grades only amount to about 33 per cent. of the possible output. A great part of this low-grade material has gone to South America. It would appear, therefore, that the British manufacturer has little to fear from Germany as far as the paper industry is concerned.

Aluminium Ware.—One rather fine exhibition of aluminium kitchen utensils, cigarette cases, &c., was seen. The head of this firm stated that owing to the coal shortage there were now not more than 400 tons per month of raw aluminium blocks produced out of a possible total output of 4,000 tons. He further stated that he had booked up orders at the fair to keep his factory in Hamburg going for six months, and that many more orders could have been accepted if the raw aluminium could have been obtained. Most of his contracts were made with German, American and Dutch buyers.

Building Trade (Constructional Material).—The exhibits were of interest as showing the efforts being made to offer the German public materials which require less coal for their manufacture than those used in the past. Many machines for the manufacture of substitute materials from various factory waste products were in evidence. Various clay and natural cement substitutes were offered in lieu of Portland cement, which requires about half its weight in coal for manufacture. Much artificial marble (from Gypsum) was also seen. On all sides were offered gaudy substitutes in lieu of the genuine article.

Textiles.—Textile exhibits were poor, mostly made of shoddy; there was also a great display of paper carpets, rugs, tablecloths, &c. The prices of these paper textiles were high; paper rugs, which at the distance looked like the genuine article, cost about double the pre-war genuine article. A large hosiery manufacturer of Chemnitz stated that only 5 per cent. of the workers generally employed in the great hosiery trade there were working, the factories either being closed down or operating at a tenth of their former capacity. The trouble in this case also was due to shortage of raw materials and coal. His opinion was that even if the factories could restart at full output it would be months before they would seek export trade as the German home demand was so great, owing to the shortage of textiles in the country.

The price of foreign textiles for re-selling in Germany is prohibitive, as in this case the exchange affects both the price of the raw materials and the labour of manufacturing.

The whole fair showed the desire of the German nation to work and recover itself, but everywhere one was struck with the hopeless dependency of Germany on foreign raw materials and increased coal output. In fact, with the German glass, pottery, textile, leather, toy and many other industries closed down, or operating at 5 per cent. or 10 per cent. of their normal capacity, due to inability to purchase raw materials at the present value of the mark, the fair gave direct evidence of Germany being at present in a very difficult position.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—The termination of the railwaymen's strike has cleared the air, but the continuance of suspension of operations at the foundries is prejudicing industrial prospects. One or two pig-iron furnaces were able to keep going on slack blast during the railway strike, and they are being got away fairly well, but all the others had to be damped down, and not only will it take some days to set them running again, but for a while they are bound, through their recent enforced idleness, to turn out inferior iron of which there is already an abundant supply. Foundry iron is very scarce. Home demand is quiet, but there is heavy Continental inquiry, and export licenses are much less difficult to secure than they have been. Some makers are now refusing to sell foundry pig-iron unless the purchaser will, at the same time, buy an equal quantity of forge iron, and this customers generally are not prepared to do. For home consumption, No. 3 g.m.b. Cleveland pig-iron and No. 4 foundry are 160*s.*; No. 1 is 164*s.*, and No. 4 forge, 157*s.* to 160*s.*; whilst export prices are 5*s.* above these quotations.

Hematite Iron.—Hematite furnaces are in the same position as those making Cleveland pig-iron. One firm has managed to keep going fairly well on slack blast, but nearly all the furnaces have had to be damped down. Nos. 1, 2 and 3 East Coast brands are 200*s.* for home use, and 205*s.* for shipment abroad, and No. 1 is 202*s.* 6*d.* for home purposes, and 207*s.* 6*d.* for export.

Foreign Ore.—Business in foreign ore is practically at a standstill. Consumers are well placed, having considerable stocks, and good contracts made, so that they are not in the market to buy at present. Rubio, of 50 per cent. quality, is in the neighbourhood of 53*s.* ex-ship Tees.

Coke.—A fair supply of coke is coming forward, but it promises to be no more than is needed. Average blast-furnace kind is 48*s.* at the ovens; and low phosphorus 49*s.* 6*d.* at the ovens.

Ironworkers' Wages.—Under sliding scale arrangements, puddling and other forge and mill wages in the North of England are increased by 5 per cent. for the months of October and November. This is due to the secretaries to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England having certified the average net selling price of iron bars and angles for the two months ending August 31 last, at 21*l.* 10*s.* 1·39*d.* per ton, as compared with 20*l.* 19*s.* 1·73*d.* per ton for the previous two months.

Blast-furnacemen's Wages.—The average net selling price of No. 3 Cleveland pig-iron for the three months ending September 30 last has been certified at 154*s.* 4·94*d.* per ton as compared with 144*s.* 11·74*d.* per ton for the previous quarter. This means an advance in North of England blast-furnacemen's wages of 20·75 (20¾) per cent., which raises wages from 137·25 (137¼) per cent. above the standard to 158 per cent. above the standard.

Manufactured Iron and Steel.—Little new is ascertainable concerning manufactured iron and steel. Up to the present there has not been a very general resumption of operations at the various works, but as material comes to hand, the different departments will be re-started. New business is on a very limited scale. Export prices

are still matter of individual negotiation, but may be given as a little above the following, which govern home trade:—Common iron bars, 22*l.*; marked bars, 25*l.*; strip iron, 23*l.* 5*s.*; black sheets, 24*l.*; galvanised sheets, 30*l.*; steel ship, bridge, and tank plates, 18*l.* 5*s.*; steel angles, 17*l.* 15*s.*; steel boiler plates, 21*l.* 10*s.*; steel joists, 17*l.* 10*s.*; and heavy sections of steel rails, 16*l.* 10*s.*

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—At least a week must elapse after the complete settlement of the railway trouble before the South Yorkshire engineering trades can resume full production. The railway strike, coming immediately on top of the Sheffield tram strike and the moulders' dispute, has done serious damage to the staple industries. Steel output has suffered the loss of some hundreds of tons at a time when every effort was being made to increase production, and new schemes to attract overseas trade and counterbalance the slump in armament and naval shipbuilding have been shelved. Efforts to maintain partial activity and prevent a complete paralysis of industry have been successful. South Yorkshire alone organised a fleet of over 12,000 motor lorries largely for the distribution of manufactured goods. By the same means sufficient coal has been imported from the South Yorkshire and Derbyshire pits to enable works to keep going at reduced pressure. Two of the largest engineering firms in the district solved the problem of fuel supply by running their own locomotives and wagons to and from the nearest pits. There has been no lack of inquiries from oversea buyers for Sheffield steel and tools, but local manufacturers have fared badly in competition with foreign competitors, being unable to specify delivery either on a given date or within a given period. Railway construction works have a fair number of orders on their books for axle, tyre and wheel renewals, but do not expect to be really busy until the new programmes for rolling-stock are drawn up. These are overdue, and the work may be expected any moment, providing the outlook is such as to warrant substantial expenditure in this direction. America is taking a fair tonnage of high-speed steel from Sheffield, but if the American proposals to tax tungsten imports of all descriptions are put into effect, Sheffield trade will suffer, and an impetus will be given to America's high-speed steel trade. Pressure on output in the lighter trades appears to be increasing rather than diminishing. File-makers have more orders on their books than they can meet by normal running. The demand for pliers, pincers, wire and small tools and implements is also maintained at an exceptionally high level. To meet this, mass production is being organised by the extension of drop-forging methods, and the wider utilisation of machinery and labour-saving methods. As soon as conditions settle down in the labour world, users of steel billets will be compelled to place substantial orders to cover contract commitments, stocks being at a very low ebb.

South Yorkshire Coal Trade.—Business in the open market is still in a state of suspension. Owing to the close proximity of pits, the staple trades have been more fortunately placed than others dependent for supplies on long-distance haulage. Most of the pits have maintained part-time production. Output that could not be disposed of by road transport or the railway skeleton service has been put into stock pending an improvement in the general position. Ample supplies have been available for household purposes, pits being unable to meet inland contracts, but the Coal Controller has kept a close watch on all deliveries, which have been restricted to emergency ration proportions. Nominal quotations:—Best branch handpicked, 33*s.* to 34*s.*; Barnsley best silkstone 33*s.* to 33*s.* 6*d.*; Derbyshire best brights, 31*s.* to 32*s.*; Derbyshire house coal, 28*s.* 6*d.* to 29*s.*; Derbyshire best large nuts, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.* 6*d.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The past week has been more or less a complete blank in the Scotch steel trade owing to the unfortunate stoppage of the railway workers. The shortage of coal and the inability to get finished steel away caused an early stoppage of work, but now that a settlement has been made the various steel works are getting under weigh again, and by the beginning of next week it is expected that conditions approaching normal will be fairly general. So long as the railway trouble existed neither buyers nor sellers were disposed even to talk of new business, but this week negotiations have been set going again and inquiries for future lots have been very satisfactory. Especially is this the case for export, brought about largely by the present labour troubles in America, but the local producers are so much occupied in their endeavour to supply the heavy demands of home consumers that shipment orders cannot be faced to any extent in the meantime. The market is very firm, and there is no inclination, nor yet does there seem any need, to shade prices.

Malleable Iron Trade.—Owing to the railway strike the malleable iron works in the West of Scotland were forced to go easy, and the majority had to stop altogether. This state of affairs was very unfortunate as there existed a very large and pressing demand for finished iron, and order books were well filled up. With the close of the strike every endeavour has been made to get into working order, but the congestion on the railways is taking days to get cleared off, and a little time must elapse before the industry gets into its proper stride again. The bulk of the present output is entering into local consumption and shipment business continues very small.

Scotch Shipbuilding.—During the month of September there was a very satisfactory output of new tonnage from the Scotch shipbuilding yards, and the industry continues in a very healthy condition. The output from the various Scotch yards last month was as under:—

	Vessels.	Tons.
The Clyde...	22	69,233
The Forth	3	6,860
The Tay	—	—
The Dee	3	1,870
Total	28	77,963

For the nine months to date the figures are:—

	Vessels.	Tons.
The Clyde...	206	416,812
The Forth	23	37,111
The Tay	10	13,368
The Dee, and Moray Firth	38	9,001
Total	277	476,292

The output from the Clyde yards during September was very good, and compares favourably with the same month in former years, being well over the average. It was also the third highest month's total for this year, and brought the nine months' total up to 416,812 tons, which has only been exceeded on five occasions since 1904—excluding the past four years, for which figures are not available. Not many fresh contracts have been reported, but it is understood that several have been booked.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—The coal market has not yet had time to recover from the effects of the railway strike. Work at all the docks has been resumed, but it is not expected that anything like normal conditions will be restored until next week as the sidings are congested with traffic, on which the railways are unable to concentrate their main energies until accumulations of food and perishable goods have been dealt with. Thus empties are going back to the collieries slowly, and this retards a full resumption of work at the pits and lessens the quantities of coal arriving at the docks. There is an ample supply of tonnage, and as there are big stocks of coal on the docks tipping operations should be busy for the rest of the week, by which time it is hoped that the flow of traffic to and from the docks will have reached something like normal. Operators are confining their attentions principally to the shipment of coals purchased prior to the strike and the local representative of the Coal Controller has to a very large extent waived the usual official regulations with the object of accelerating shipments, though where practicable British tonnage is given the preference. The Coal Mines Department has also extended the validity of licences for shipment to neutral countries to October 25, and provision has been made for the extension of third-quarter French licences in special circumstances. Prices are irregular and, with little business passing, it is difficult accurately to give quotations, as everything depends on the individual circumstances of buyer and seller. Generally, quotations are about 2*s.* 6*d.* higher than prior to the stoppage. Best Admiralty large coals command up to 85*s.*, best Monmouthshires 82*s.* 6*d.*, and good dry large 80*s.* Best steam smalls are worth 62*s.* 6*d.*, ordinaries 57*s.* 6*d.* and inferiors from 40*s.*, while in the bituminous section, No. 2 Rhondda large commands about 75*s.* and throughs 62*s.* 6*d.* Coke is on the basis of 102*s.* 6*d.* and patent fuel 80*s.* Pitwood remains plentiful and weak from 52*s.* 6*d.* The question of supplies to inland consumers is to receive early attention, and in the meantime collieries have been officially instructed to adopt such a course as will enable them to restart their pits and keep them working pending agreement on a priority list. Exports from South Wales last week, exclusive of Admiralty shipments, amounted to 200,785 tons, compared with 377,989 tons in the preceding week. Of last week's shipments, 69,601 tons, or 39 per cent., went to France, against 161,468 tons in the previous week, 36,390 tons to Italy, 25,580 tons to South America, 12,792 tons to Spain, 3,072 tons to Portugal, 48,852 tons to British coaling depôts, and 4,498 tons to other countries. In the week ending September 27 outputs in the Monmouthshire and South Wales coalfield reached 915,814 tons, the lowest quantity raised since the introduction of the 7-hours' day.

AUSTRIAN ENTERPRISE IN THE FAR EAST.—An Austrian pamphlet, written in English, and advertising a grinding machine, was recently received by a British consulting engineer in Bangkok from a well-known Austrian firm. It is of interest as showing that no time is being lost by enemy firms in their attempt to enter the world's markets once more. Pre-war trade in this class of machinery with the Siamese market was done for the most part with Germany and Austria, and strenuous efforts will no doubt be made by firms in the latter countries to regain the market. If British firms wish to maintain any trade which they may have captured in the Siamese market during the war, particularly in the above type of machinery, they will need to be especially enterprising and watchful. A copy of the pamphlet describing the machine may be seen at the Inquiry Room of the Department of Overseas Trade, 73, Basinghall-street, E.C. 2.

NOTICES OF MEETINGS.

THE MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday evening, October 11, at the Grand Hotel, Manchester, the chair will be taken at 7 p.m. The business will be: (1) Presentation of the "Constantine" Gold Medal to Mr. H. E. Thomas, Member, for his paper read during the last session, entitled "Automatic Machines"; (2) presentation of the "Butterworth" Gold Medal for contributions to the discussions during the past session, awarded to the late Mr. Frank Foster, M.Sc.; (3) Inaugural Address by the President, Mr. Harold F. Massey, B.Sc., M.I.Mech.E.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, October 16, at 5.30 p.m., at the Rooms of the Geological Society, Burlington House, Piccadilly, London, W. 1, the following papers will be submitted for discussion: "Prospecting for Gold and other Ores in Western Australia," by Mr. C. M. Harris, Member; "Coral Island Phosphates in the Making," by Mr. F. Danvers Power, Member.

THE BIRMINGHAM METALLURGICAL SOCIETY.—Thursday, October 16, at 7 p.m., at the Birmingham Chamber of Commerce, New-street, paper by Mr. W. H. J. Vernon, A.I.M.M., "Notes on Corrosion of Metals."

THE OPTICAL SOCIETY.—Thursday, October 16, at 7.30 p.m., when the following communications will be received:—"The Unaided Eye" (Part II), by Mr. J. W. French, B.Sc.; "Projection Screens," by Mr. Chas. W. Gamble, M.Sc. (Tech.).

PERSONAL.—It is officially announced that Mr. Frank Shearman, chairman and managing director of the Mount Stuart Dry Docks, Limited, Cardiff, has been appointed to a seat on the Board of Messrs. J. Samuel White and Co., Limited, the well-known shipbuilders and engineers of Cowes, Isle of Wight. Mr. Shearman is connected with several engineering and ship-repairing establishments in South Wales, and is also chairman of the Times Shipping Company, Limited, of Cardiff.

EXHIBITIONS OF BRITISH GOODS AT SAO PAULO.—We read in *The Board of Trade Journal*, that in order to ensure the success of the series of exhibitions which is being held at Sao Paulo by the British Chamber of Commerce of Sao Paulo and Southern Brazil, it has been resolved that British merchants and exporters, as well as manufacturers of British goods, shall be invited to participate. The first of the series of exhibitions (textiles), has had to be posponed for a few months, but it is hoped that the second, covering hardware and trades allied to that industry, may be inaugurated not later than January 1, 1920, to be followed by an exhibition of fancy goods on or about April 1, 1920. The object of the Chamber in arranging for this series of exhibitions is solely that of encouraging the sale of British-made goods in the Brazilian market, and it is hoped that British merchants and exporters will take advantage of this opportunity to bring their goods to the notice of local buyers.

THE RAILWAY STRIKE AND COAL CONSUMPTION.—With reference to our paragraph on page 446 *ante*, the Board of Trade now make the following announcement with regard to the effect of the termination of the strike on restrictions in the use of coal and coke, gas and electricity. The Lighting, Heating and Power (Emergency) Order, 1919, prohibiting display lighting, has been revoked. In view of the danger of a severe shortage of coal in the winter owing to the diminution of stocks during the strike, it is necessary to maintain for a short time the restrictions imposed by the Coal and Fuel (Emergency) Order, 1919, limiting deliveries of coal to 1 cwt. The Controller of Coal Mines will, however, authorise the relaxation of the restriction in those districts in which, in his opinion, this may safely be done. The Gas and Coal (Emergency) Order, 1919, which prescribes a maximum calorific value of 425 Board of Trade units gross, and provides for the diminution of pressure in case of necessity, will also remain in operation. The embargo which local fuel overseers were instructed to place on 25 per cent. of all industrial stocks in their districts has been removed.

THE AGRICULTURAL AND GENERAL ENGINEERS, LIMITED.—The following firms have amalgamated: Messrs. Aveling and Porter, Limited, Rochester; Messrs. E. H. Bentall and Co., Limited, Heybridge; Messrs. Blackstone and Co., Limited, Stamford; Messrs. Richard Garrett and Sons, Limited, Leiston; and Messrs. James and Frederick Howard, Limited, Bedford. Most of these firms have been established well over 100 years. The amalgamation will be known as "The Agricultural and General Engineers, Limited," with a capital of 3,000,000*l.* sterling, formed with a view of employing a large amount of British labour on mass productions. The firms entering the amalgamation will in no sense lose their identity, nor is the management to be changed, the whole object of the amalgamation being massed production and an efficient selling organisation. The various works will specialise in their chief products. They will be greatly extended, and already a great amount of this work and the purchase of new tools has been undertaken. The head offices of the amalgamation will be at Central House, Kingsway, London, but until the Government Department, which is now in possession of Central House, have removed (which will be in the course of the next two months) the temporary offices are at 50, Pall Mall, London, S.W. 1.

A MARINE-ENGINEERING WORKS LABORATORY.

(*For Description, see Page* 467.)

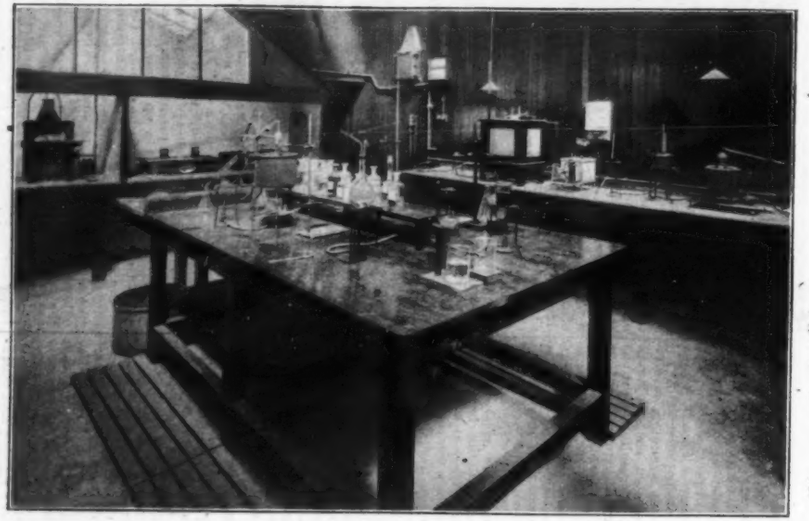


Fig. 2. Chemical Laboratory.

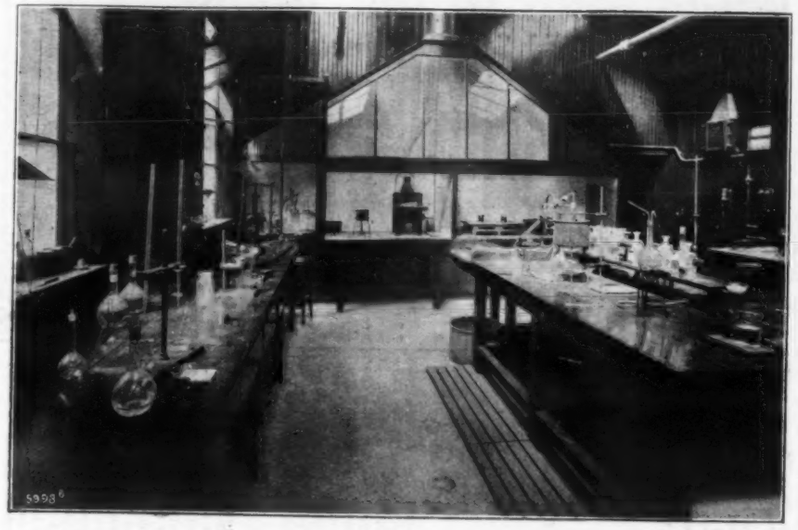


Fig. 3. Chemical Laboratory.

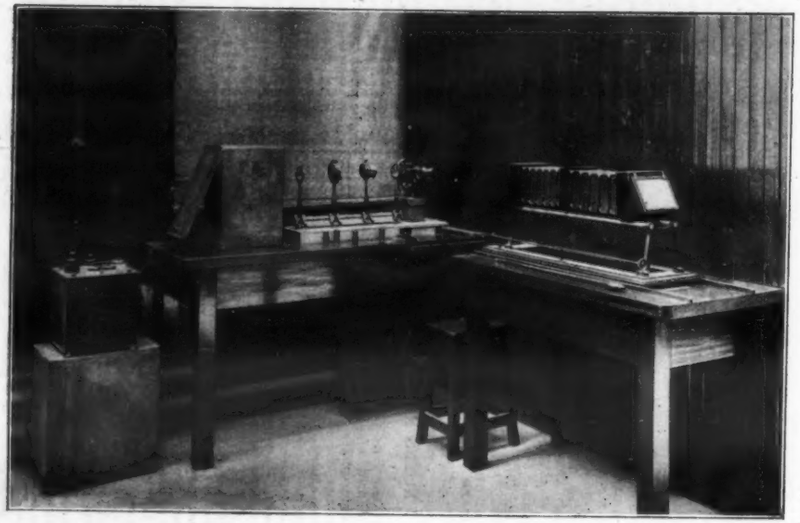


Fig. 4. Photo-Micrographic Apparatus.

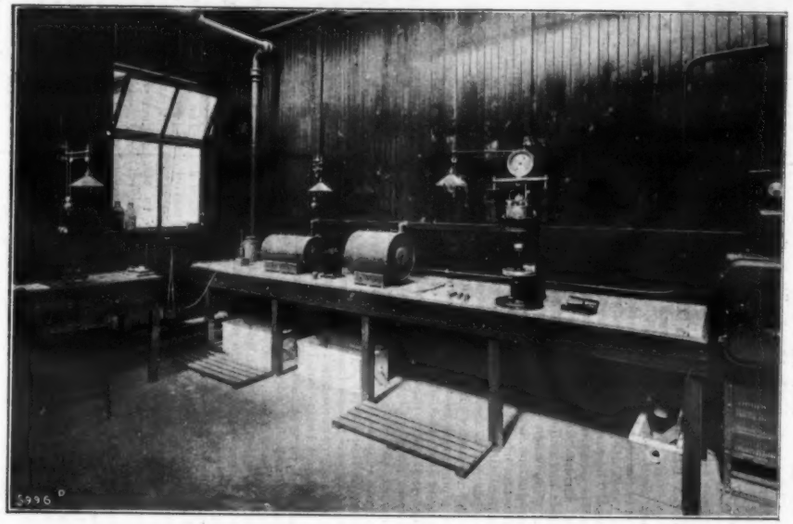


Fig. 5. A Corner of the Physical Laboratory.

GEARED TURBINES IN THE SWEDISH NAVY TORPEDO-BOAT DESTROYER "WRANGEL."

CONSTRUCTED BY THE DE LAVAL STEAM TURBINE COMPANY, STOCKHOLM.

Fig. 7.

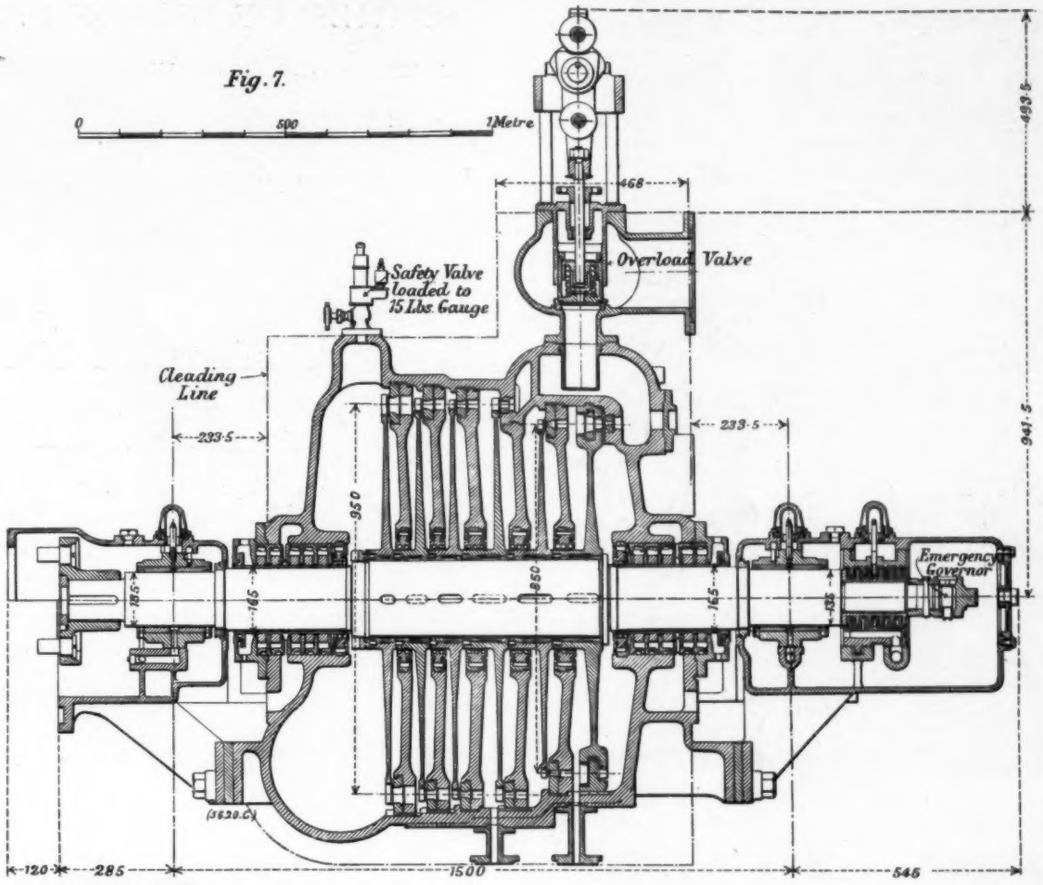


Fig. 8.

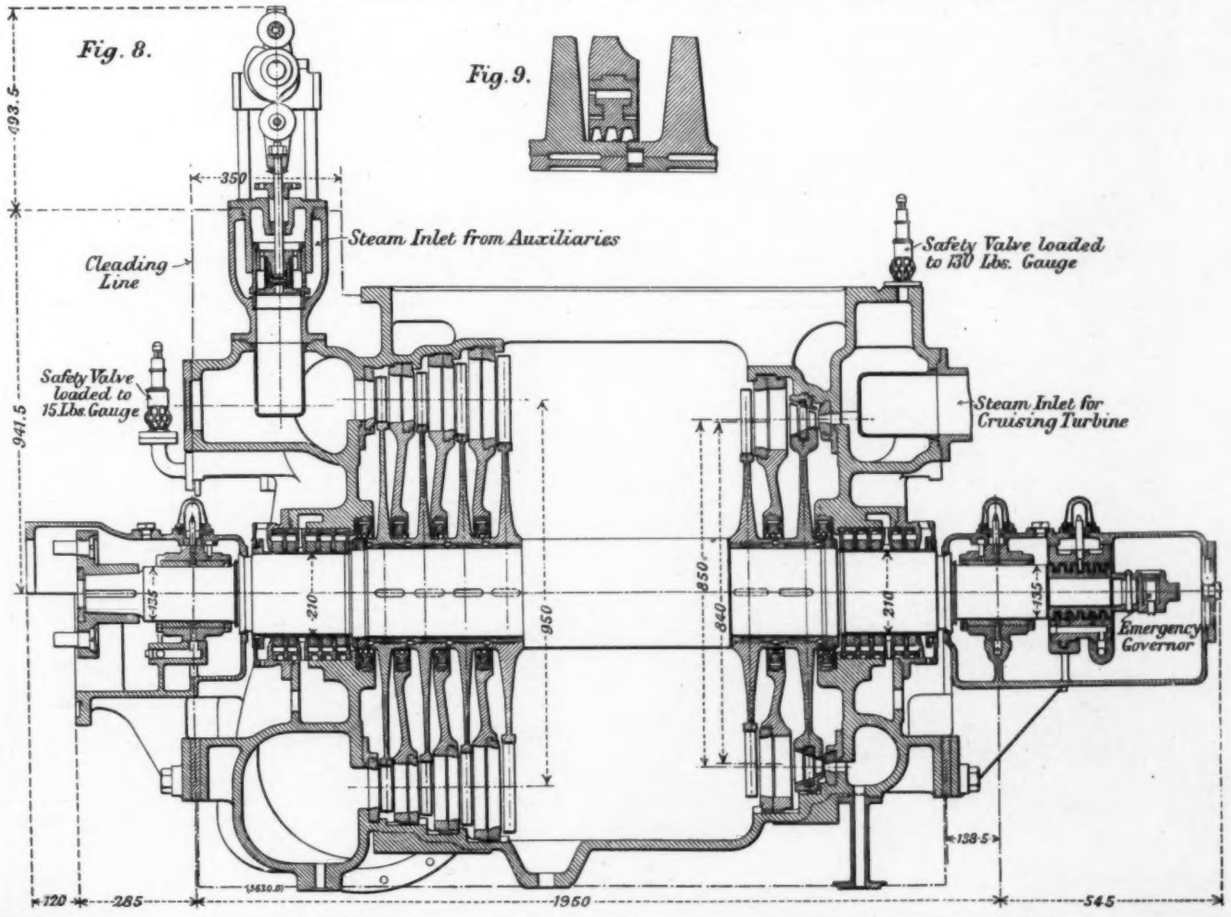


Fig. 9.

(*To face page* 472.)

GEARED TURBINES IN THE SWEDISH NAVY TORPEDO-BOAT DESTROYER "WRANGEL;" DETAILS OF GEARING.

CONSTRUCTED BY THE DE LAVAL STEAM TURBINE COMPANY, STOCKHOLM

(*For Description, see Page* 471.)

Fig. 10.
SECTION D.D

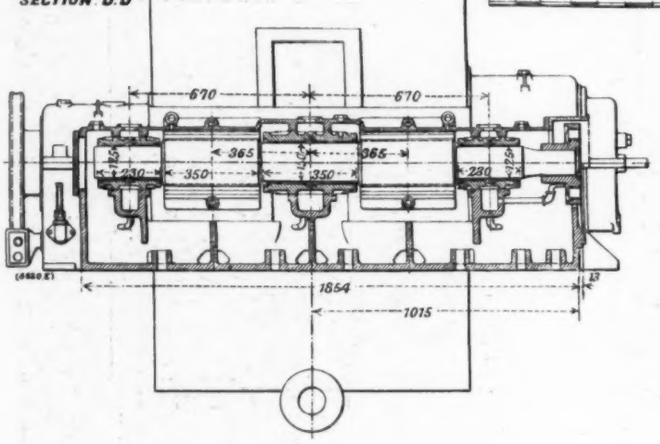


Fig. 11.
SECTION E.E. SECTION F.F.

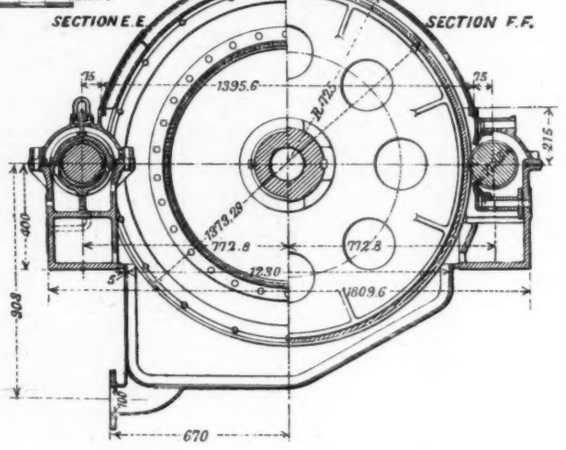


Fig. 12.
SECTION A A.

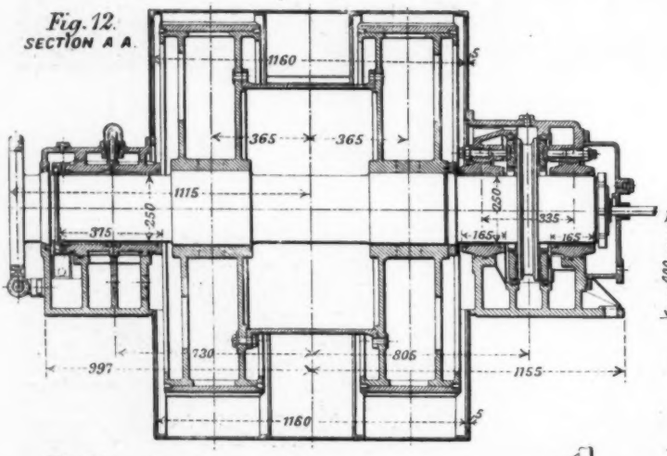


Fig. 13.
SECTION B.B LOOKING FORWARD.

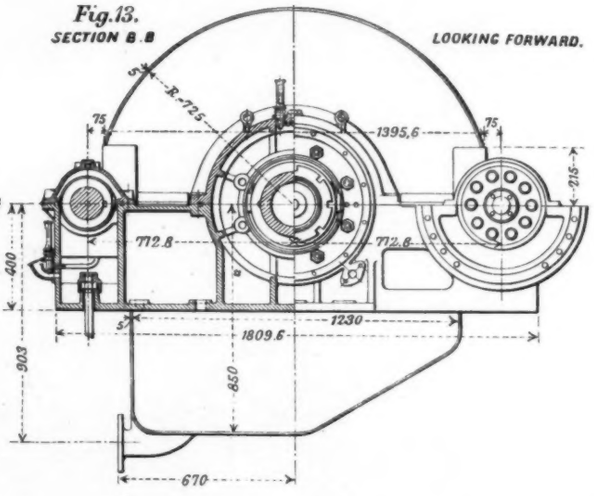


Fig. 14.

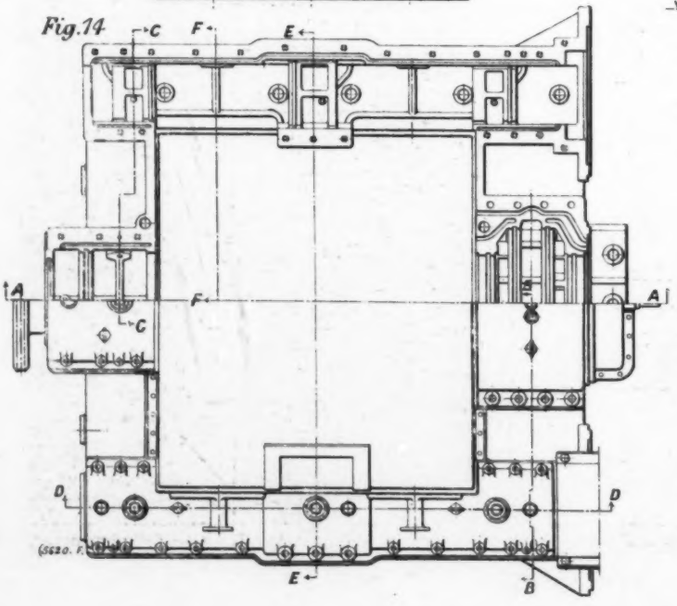
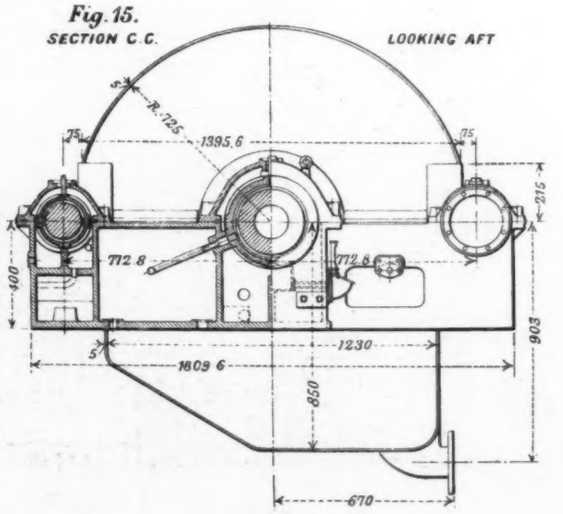


Fig. 15.
SECTION C.C. LOOKING AFT



GEARED TURBINES IN THE SWEDISH NAVY TORPEDO-BOAT DESTROYER "WRANGEL."

CONSTRUCTED BY THE DE LAVAL STEAM TURBINE COMPANY, STOCKHOLM.

(*For Description, see Page* 471.)

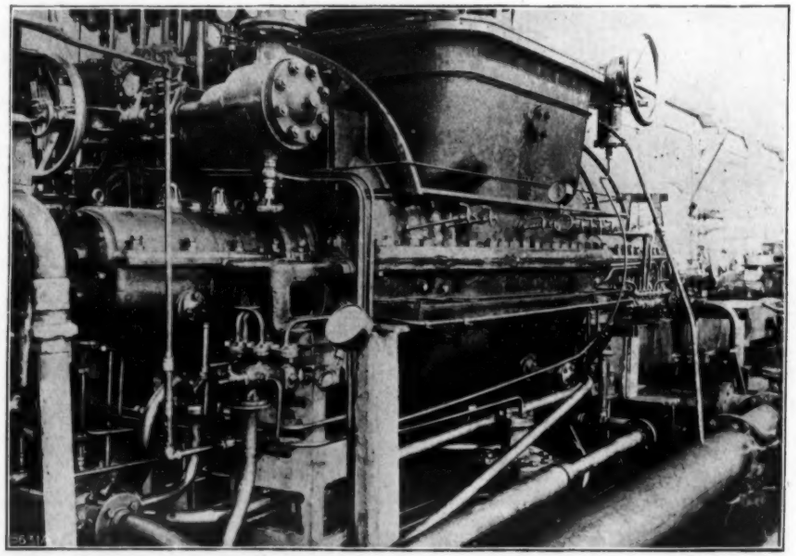


FIG. 16. LOW-PRESSURE TURBINE WITH EDUCTION-PIPE TO CONDENSER.

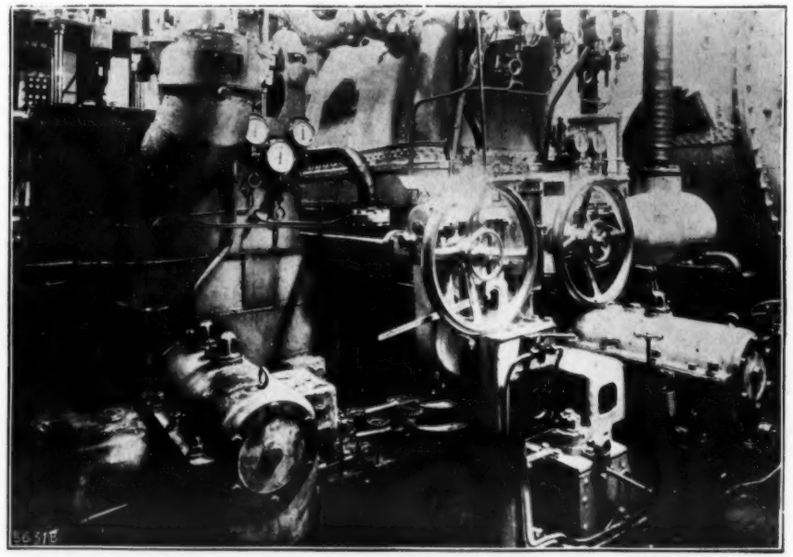


FIG. 17 FORWARD END OF PORT SET OF TURBINES.

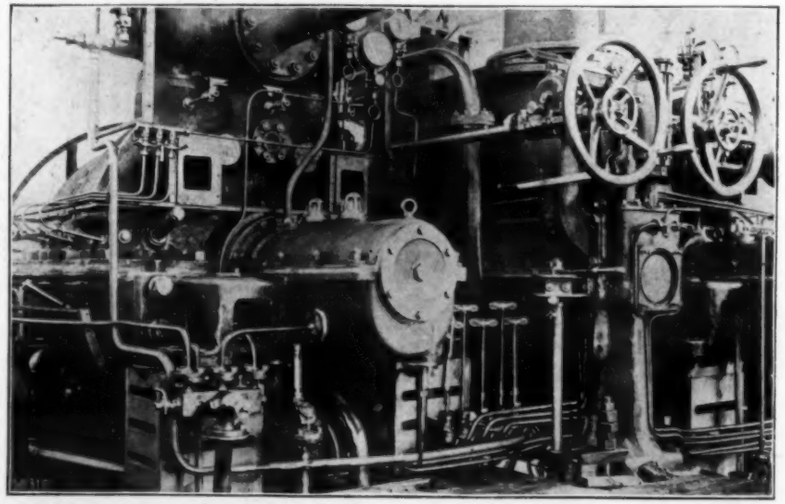


FIG. 18. PORT SET OF TURBINES.

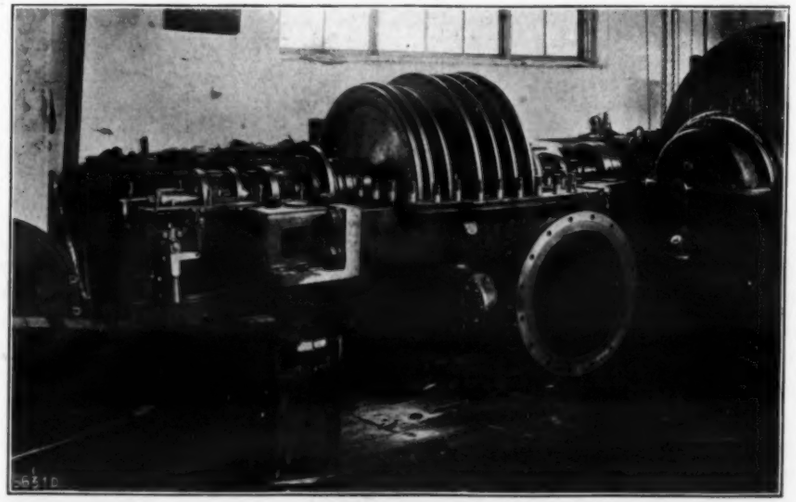


FIG. 19. HIGH-PRESSURE TURBINE WITH UPPER PART OF CASING REMOVED.

GEARED TURBINES IN THE SWEDISH NAVY TORPEDO-BOAT DESTROYER "WRANGEL."

CONSTRUCTED BY THE DE LAVAL STEAM TURBINE COMPANY, STOCKHOLM.

(*For Description, see Page* 471.)

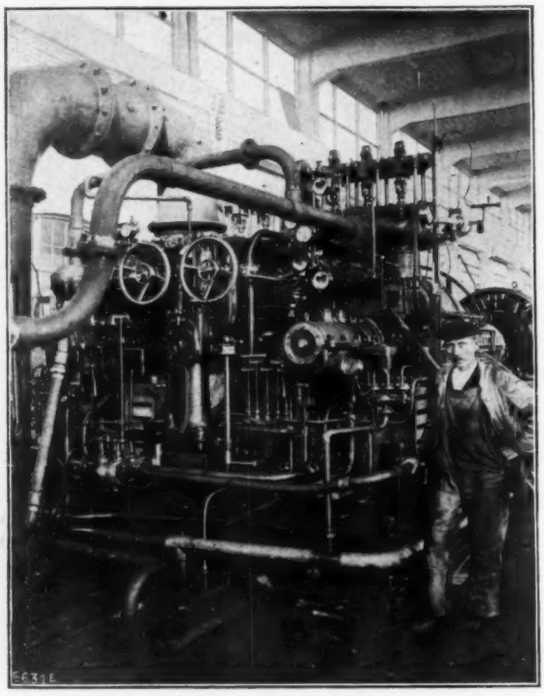


Fig. 20. View of Starting Platform.

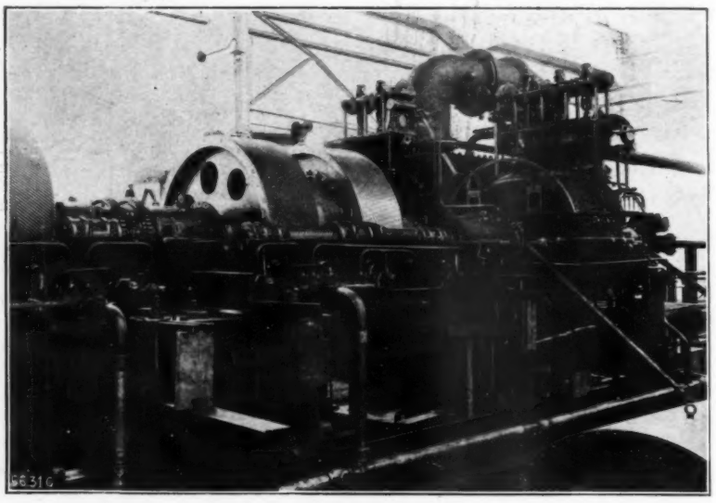


Fig. 22. View from Aft End of Set.

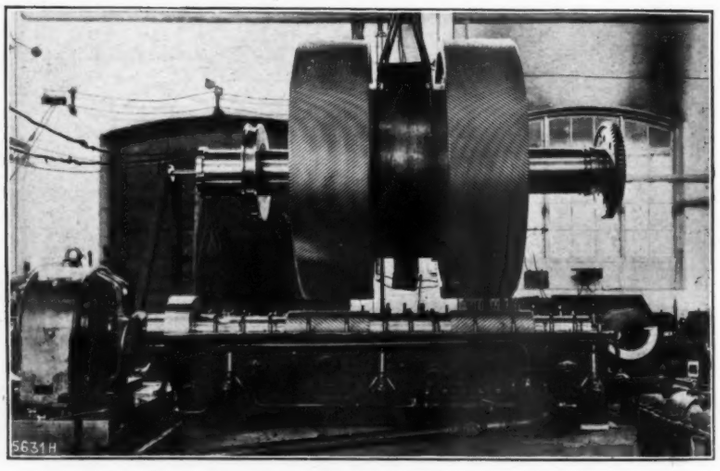


Fig. 23. View showing Gear-Wheel and Spindles.

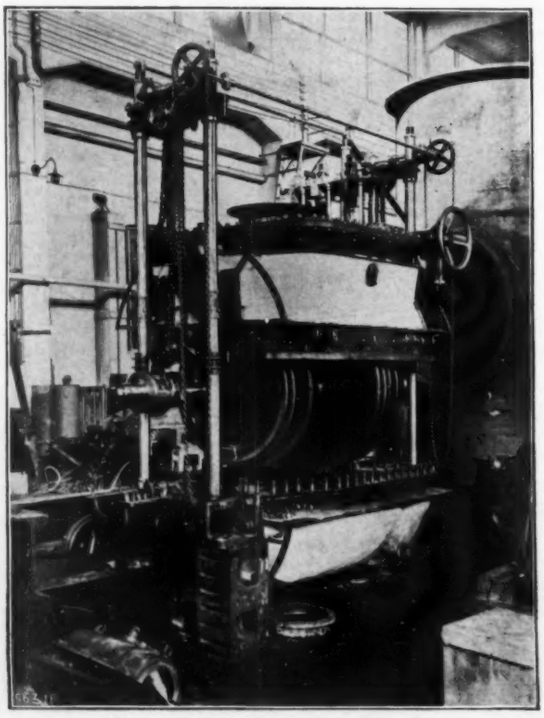


Fig. 21. Casing and Rotor Lifting Gear.

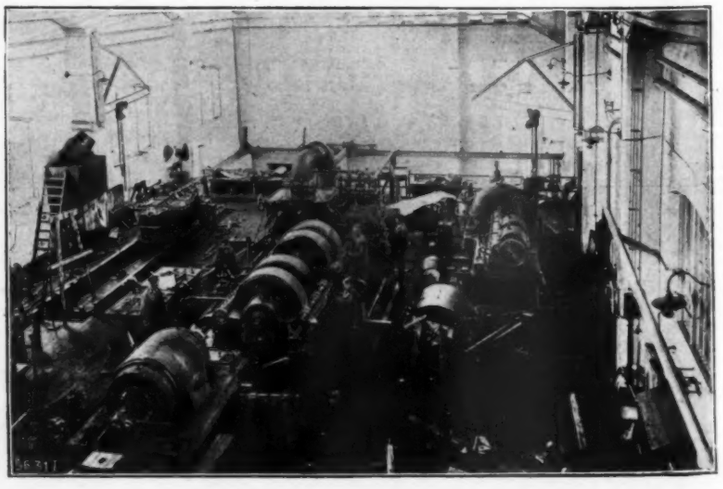


Fig. 24. View of Component Parts of Turbine Set.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication, and certainly not later than Monday morning.

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NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 481.

ENGINEERING.

FRIDAY, OCTOBER 10, 1919.

UNDERCOOLED STEAM.

IN a series of articles which appeared in our columns during July and August last year reasons were set forth in favour of the view that when wet steam is expanded through a steam turbine it never attains a condition of thermal equilibrium until the condenser is reached. The volume corresponding to a given pressure is therefore always smaller than would follow from the ordinary theory, and it was shown that on this basis a rational explanation might be found for the observed values of the superheat and vacuum corrections.

In the criticisms to which the above hypothesis has so far been subjected there appears to be a disposition to accept the view that supersaturation does persist down to the "Wilson" line, but there has seemed to be more hesitation in admitting that thermal equilibrium is not re-established at the Wilson line and maintained throughout the remainder of the expansion. Part of the evidence in favour of this section of the new theory is admittedly indirect, but it is not wholly so, and there is some very direct evidence in favour of the view that the condition of supersaturation presents. In the first place Mr. Wilson found that when the expansion was prolonged beyond the "Wilson" line the number of droplets formed was enormously increased, showing that those already in existence ceased to act as effective centres for condensation once they had attained a certain size, and any further condensation had accordingly to take place on other nuclei, which is possible only when the steam is undercooled by some tens of degrees. Again, the exhaust temperature of a turbine as measured by a thermometer appears, in normal working conditions, to be invariably a little below that corresponding to the pressure. Were this discrepancy an apparent one merely, due to erroneous measurements of the pressure, it would be natural to expect that the thermometer readings would be as often too high as too low. In fact, in Mr. Allen's condenser experiments, in which one object aimed at was that the steam should be just dry as it entered the condenser, the thermometer readings were in excess of that due to the pressure. The high reading may have been due in part to the adiabatic compression of the current of steam against the wall of the thermometer pocket. This peculiarity in Mr. Allen's experiments affords evidence that the use of an ordinary thermometer pocket does not (in the case of wet steam) inherently result in low readings and, in fact, in the case of wet or saturated steam known to be at its normal temperature, no very special precautions are required to ensure consistent thermometer readings. With superheated steam on the other hand the pocket should have very thin walls and have a series of deep collars turned on it near its lower end, so as to expose a maximum surface to the steam of which the temperature is to be measured, and a minimum area for loss of heat by conduction along the "stem" of the pocket. In the case of supersaturated steam no thermometer, whether mercurial or electric, can in the very nature of things give any reliable indication of the steam temperature. All that can be said is that at the best the reading cannot give too low a temperature, and that in most cases any defect of temperature shown must be only a fraction of the real defect.

It has been suggested in one discussion on the supersaturation hypothesis, that the turbulence of the steam flow through a turbine, may tell against the occurrence of undercooling. It is very difficult indeed to see how turbulence or eddies can materially affect the matter. It is a well-known principle in physics that if any change of state involves either an increase of pressure or the performance of external work, that change takes place with difficulty. A "catalyst" is commonly necessary to make the change possible. In the case of supersaturated steam, not merely has work to be done in forming the surface films of the droplets, but the ultimate effect of the change from the undercooled condition is an increase in the volume occupied. The presence of a catalyst is thus doubly necessary, and this is for the most part provided by the Wilson nuclei, which are molecules having the constitution H_4O_2 or perhaps H_6O_3, or even possibly H_8O_4. The existence of these compound molecules in steam is proved by a comparison of the theoretical and actual volumes occupied by unit weight of the steam. One of the best established results of the kinetic theory of gases is that the number of molecules in a gas which occupies a given volume at a given pressure is constant. This holds, whatever may be the constitution of the gas. Whether it be pure hydrogen, say, or a mixture of gases such as air is.

Experiment shows that a litre of oxygen at a temperature of 100 deg. C. and at atmospheric pressure weighs 1·0465 grammes, and contains $1·980 \times 10^{22}$ molecules. A litre of dry steam at the same temperature and pressure must contain exactly the same number of molecules. If it consisted solely of molecules represented by H_2O it would accordingly weigh $\frac{18·016}{32} \times 1·0465 =$ 0·58925 grammes. Actually it is found to weigh 0·5981 grammes, so that evidently some of the molecules present must be heavier than those represented by the formula H_2O. Certain of the molecules present are accordingly double or treble molecules, which are, of course, continually splitting up, whilst fresh molecules co-aggregate, the condition being thus one of statistical equilibrium. In the case of certain gases, the duration of each union is at ordinary temperatures so short that the number actually co-aggregated at any instant is insignificant, and the density of such gases can accordingly be calculated directly from the chemical formula. This is not the case with steam at ordinary temperatures and pressures. Assuming that the co-aggregated molecules have the formula H_4O_2 the number of these present in 1 lb. of dry steam at 100 deg. C. and at atmospheric pressure is about 24×10^{22}, whilst at 40 deg. C. corresponding (roughly) to a vacuum of about 28 in., the number of co-aggregated molecules in 1 lb. is reduced to $3·7 \times 10^{22}$.

It is on these co-aggregated molecules that condensation occurs when the expansion is carried far enough. The number present depends solely on the temperature and pressure of the vapour and is quite unaffected by turbulence. The most the latter can do is to thin the layer of high temperature steam which blankets any solid surface exposed to supersaturated steam. The amount of such surface exposed in a turbine is, however, comparatively small, and much of it is necessarily at a relatively high temperature. Thus as the steam enters the moving buckets of an impulse wheel it is compressed adiabatically against the concave faces of these buckets. The corresponding rise of temperature is substantial, and as a consequence the temperature of the moving blades is materially higher than it would be if they were merely immersed in quiescent steam at the same temperature and pressure. The surface they expose will therefore be comparatively ineffective for condensing purposes. As regards the guide blades there is direct evidence that wet steam expanded through them is undercooled since the discharge is known to exceed that theoretically possible, on the assumption that thermal equilibrium is attained.

As already stated, the presence of a catalyser of some kind is necessary for condensation to occur. The condition of thermal equilibrium is more stable than that of supersaturation, but to pass from the one state to the other involves the performance of work. The energy liberated on condensation is not instantaneously available to this end, as time is

necessary for its conversion into the form of heat. The presence of a catalyser, however, makes it possible for the transformation to take place in two stages. In the first stage condensation occurs without development of heat, and with a consequent contraction in volume. In the second stage the energy liberated on condensation is converted into heat and absorbed by the vapour which increases accordingly in volume or pressure. It is probable that the transformation is for the most part completed within a very small fraction of a second.

From this point of view it is evident that when condensation occurs at the Wilson line there must be at least a temporary diminution of volume, and there would seem to be reasons for believing that this decrease in volume is considerably greater than it would be if the weight of steam at first condensed were only that requisite to the ultimate attainment of thermal equilibrium. The condensation comes down in the first instance as droplets, which are smaller than those known to show the Brownian movements. They may thus be considered as equivalent to molecules of a very dense gas, and will not therefore add to the frictional resistances experienced by the steam as it passes through the turbine. When, however, such droplets coalesce to form large drops, the conditions are changed, and it appears quite conceivable that such large drops may give rise to increased losses in nozzles and blading. There appears to be some direct evidence in favour of this view.

In sudden and abrupt changes of any kind the equilibrium condition seems to be invariably overshot. Reasoning from this analogy, it would seem that the condensation of steam at the Wilson line will be excessive, and expansion beyond the Wilson line will begin accordingly with a volume not intermediate between the "equilibrium volume" and the volume corresponding to no condensation, but may actually be considerably smaller than the latter. How long such an excess of condensation persists is, of course, a matter for enquiry. It may be merely momentary, or it may endure for an appreciable time. If this be so, an expansion beyond the Wilson line will proceed with an initial volume smaller, and a final volume greater, than was provisionally assumed in the articles published last year.

Moreover, there seems good reason for believing that the temperature of the steam during such an expansion is always very approximately the corresponding Wilson temperature. Thus when expanded to 1 lb. per square inch absolute, the "instantaneous" temperature of the undercooled steam will be very approximately 0 deg. C. and the volume will depend upon the dryness fraction, so that there is on this view a somewhat close analogy between an expansion beyond the Wilson line, and an expansion in thermal equilibrium beyond the saturation line. There is, however, a difficulty as to the amount of energy accounted for by the droplets present in undercooled steam. The temperature of these is presumably very close to the saturation temperature corresponding to the pressure, but as the surface they present is very large, it is possible that the energy represented by surface tension may not be entirely negligible, and possibly there may be some not wholly insignificant fraction of the energy set free by the condensation still persisting in the "vibrational" form and not yet converted into heat.

These points constitute a subject for future research, but the considerations above advanced do afford reason for believing that it is a physical impossibility for wet steam to be discharged from an ordinary steam turbine in other than a greatly undercooled condition.

INDUSTRIAL FATIGUE IN TIN-PLATE MANUFACTURE.

Of late industrial fatigue has been the subject of much discussion, and if facts have been few, speculation has been rife. The demand for shorter hours of labour has further raised many complex problems, whose solution is probably to be found only in the accurate trade statistics of the future. Whether the fears of some, who dread the consequences of a diminished output, will be realised, or the hopes of others who believe that increased energy will compensate for loss of time, will prove well founded, cannot be settled by an academic investigation of factory environment, however acutely the inquiry may be conducted. But much may be learned of the effects that prolonged muscular exertion has on health and capacity, and of other conditions that diminish activity or stimulate production. With some such hope presumably, the Home Secretary, two years ago, invited the Department of Scientific and Industrial Research to appoint a committee "to consider and investigate the relations of the hours of labour, and of other conditions of employment, including methods of work, to the production of fatigue, having regard both to industrial efficiency and to the preservation of health among the workers." Such a committee was appointed under the chairmanship of Professor C. S. Sherrington, F.R.S., and its first fruits are embodied in a report on the operations connected with the manufacture of tinplate in South Wales, by Mr. H. M. Vernon, M.D., investigator to the board.

The work of the mill men, the only portion of the factory staff here considered, is very severe, both on account of the physical exertion required and the high temperature in which the men have to work. They are continuously employed in hauling out red hot bars or sheets of metal from the furnaces, passing these through rolling mills, doubling and folding the sheets as they are reduced in thickness, and generally lifting and manipulating the heated metal under conditions that are very exhausting. In several operations a weight of from 40 lb. to 80 lb. has to be lifted by means of long tongs, and the necessary length of leverage must make the labour very trying to the strongest physique. The temperature of the air in which the men are working has been observed to be as high as 110 deg. F., but this figure, Dr. Vernon states, gives but an inadequate idea of the heat experienced. The red hot sheets of metal average 4 sq. ft. in area, and at some stages reach 10 sq. ft. The radiant heat from such a surface must be very considerable, and the partly open furnace is also a factor that cannot be neglected. There can be no doubt but that the physical effort of mill men is strained to the utmost, and therefore no surprise need be felt that it should be proposed to reduce the hours of labour. Up to the beginning of 1919 the men worked five or six 8-hour shifts per week, consequently 40 hours or 48 hours, and now it is suggested that the length of the shifts should be reduced to six hours, and working weekly the same number of shifts, the total number of hours would amount to 30 hours or 36 hours per week.

It is eminently desirable to know what effect such prolonged strain would have on output, and Dr. Vernon has collected and discussed in a very luminous way information from five typical factories in which the conditions of labour, especially ventilation, vary considerably. Perhaps it would have been better to have asked for the effect on annual output, for in the course of his inquiry, Dr. Vernon found that the influence of outside temperature and the efficiency of the ventilating apparatus masked to some extent the effect of duration of hours. The evidence on this point does not seem to us so conclusive as it does to the author, and it is to be regretted that the reply to the definite issue submitted is not so clear as could be wished.

The conditions for a direct answer appeared excellent, because on emergency, as the breakdown of a mill or a temporary shortness of material, the custom of the trade is to convert the three 8-hour shifts into four 6-hour shifts, or even into six 4-hour shifts in order to distribute the work as fairly as possible among the operatives. At one factory 4-hour shifts had been worked regularly for some months, and apparently the output could be compared directly with that of the shift of double the length. Unfortunately one troublesome variable has to be taken into account, namely, the varying weight of the sheets handled. The number of sheets worked, or the united area of the sheets is known very approximately, for it is on this basis of area that the wages are paid, the weight being practically disregarded. In this inquiry into the amount of work performed, the unit should be the foot pound, or some such measurement, and the author has taken very considerable pains to make the comparison rigorous and uniform. The method adopted in necessarily troublesome from an arithmetical point of view, but it would be difficult to suggest an improvement, though unfortunately the accuracy of much of the inquiry depends upon the effectiveness of the standardisation. If for any length of time, as a whole summer or winter, lighter or heavier sheets were continuously worked, a systematic error of considerable amount might enter the calculations. But mathematical accuracy cannot be obtained by any method; average results must be accepted and the authors results can be accepted as legitimate.

Another determining factor has to be taken into account, one on which Dr. Vernon rightly lays some stress. Inasmuch as the men were working a shorter number of hours in the 4-hour shifts, the total weekly wages were necessarily smaller, and since payment was by piece work there was more inducement to use extra exertion. Some allowance should probably be made for this exceptional circumstance, for the men who were working only 16 or 20 hours a week would have a greater incentive to put forth their maximum effort, in order to earn as much as possible, and it may be that the comparison is set up between the maximum and the average method. No deduction, however, is made, and the conclusion drawn from the standardised figures shows that the output of the 4-hour shift arrangement is in excess of that of the normal 8-hour shift by 11·5 per cent.

For comparison of the effective work of the 6-hour with the 8-hour shift, more or less complete details are forthcoming from three factories, but the facts are not so clear and decisive as in the case of the 4-hour shift, and another disturbing factor is made evident. The work in these factories was not so uniform as in the former case, the reduction of hours was often for short periods and frequently interrupted. The author suggests from his experience in other inquiries, that workers need time to accommodate themselves to new conditions of work. A steady level of production is only attained after the worker perceives that he can speed up his rate of working without incurring over fatigue. The operation of these disturbing fluctuations is unsatisfactory, they emphasise alike the difficulty of the inquiry and its sources of error. In one factory, however, in which 6-hour shifts were worked for 96 weeks out of 193, and continuously for 15 months, the mean hour output in all the 6-hour shifts was 8·5 per cent. greater than in the 8-hour shifts, but owing to the time required for adaptation this figure is probably rather low: the real measure of improvement is, in the author's opinion, more nearly 10 per cent. Some increase may be justifiable, but the amount is arbitrary. At the third factory, as far as the evidence shows, an increase of 4·7 per cent. is declared in favour of the 6-hour shift. From these data the author concludes "with considerable probability that when 6-hour shifts are worked the hourly output is about 10 per cent. greater than when 8-hour shifts are worked. In the latter case, therefore, a correction of 5·3 has been applied for "adaptation."

Some interesting results are presented concerning the output in the successive hours of the shift, and of the length of the rest pauses at the different stages of the work. The shifts change, but the work goes on with unresting activity from early Monday morning to midday on Saturday, and at no time does the work stop for more than a few minutes, each shift following on its predecessors with automatic regularity. The entire cycle of operations that reduces the bar to the sheet (about 100 minutes in all) can be conveniently divided into five stages, and the men make a slight and necessary pause between successive stages. These pauses have been carefully timed both for length and frequency, and the result shows that the number of minutes spent in each hour in recuperation is, in the mean, 12·5 in 8-hour shifts, and 10·2 in 6-hour. The actual number of minutes worked, therefore, is in one case 47·5 per hour and in the other 49·8 per hour, and some of the extra output in the shorter shift is therefore due not to greater concentration on the operation, or any increased capacity for work, but simply that more time is given to actual work. Some 4 per cent. of the observed increase can be accounted for in this way. The human machine is not enabled to do better work, or to put out more energy in the same time, but to work more minutes.

The conclusion derived from the observation of frequency is that with a shorter spell of work, more pauses are needed, but of shorter duration than in the longer period.

Of rests of less than two minutes in length, the percentage is 55 in the 6-hour shift against 38 in the longer. But with pauses of four minutes' duration the percentage is 21 in the 8-hour shift and only 7 in the 6-hour. The number of rests per hour, in both long and short working periods, is 3·6; therefore, from the figures given above, the average recuperation pause is 3·42 minutes when employed for 8 hours, and 2·85 minutes in the shorter working shift.

The output per hour is fairly uniform throughout the whole period, certainly there is no evidence of gradual exhaustion with the lapse of time. Taking the average production for the whole 8 hours as 800, the actual hourly output varied in extreme cases from 77 to 121, but half of the output values lie between 94 and 105. In the 6-hour shift the hourly output is distinctly more uniform. The extremes range from 90 to 110 and the mean values from 96 to 105. The initial output is above the average, followed by a gradual decline, but in the final hours, especially in the penultimate, there is a noticeable increase. The variation could be explained if we might suppose "that the men start off well at first as they are fresh and vigorous, get fatigued and bored, and so reduce their output, but then, as the end of the shift or spell approaches, they tend to cheer up and put on a spurt, which dies off at the very end as they begin to make preparations for stopping work altogether."

As already intimated, Dr. Vernon has taken peculiar care to define the work accomplished on a uniform standard of weight. The number of boxes prepared for despatch is an insufficient criterion of the exertion displayed or the fatigue incurred, and he regards the weight of metal as a more satisfactory standard of measurement. When a table of the weekly output for six consecutive years from one factory is arranged, computed on the basis of weight alone, it appears that the average mean percentage of plates produced was 3 per cent. to 4 per cent. above the average from January to March, and then fell gradually to a minimum in August, when it was 4 per cent. below the average. Thence the amount rose again to 2 per cent. above the average. It is therefore claimed that the output varies inversely as the temperature: the irregularities observed are within the limits of general error. This conclusion may be legitimate, but the evidence is hardly complete. For six months of the year, from November to April inclusive, the mean temperature of each month differs from the mean of the six by only about 2 deg., yet in the six months we have a variation of 5 per cent., whereas in the months of May to November, with a far greater variation in external temperature, the output varies only from 99 to 96, and for four of these months there is absolutely no change. Later, the author extends the comparison, substituting the weekly mean temperature for that of the month. This is a slightly more rigorous test, and on the whole the new table supports the author's contention. But it must be remembered that the heat of a workshop is always high, failure of ventilation is one of the hindrances that Dr. Vernon most rightly condemns, as improvement in ventilation is as strenuously urged, and with this admitted defect on the one hand and the need of amendment on the other, there can be little hesitation in saying that the heat of the workshop is at all times above 61·6 deg., the highest quoted in the table. If the constant temperature, as we contend, is much above that outside, it is difficult to understand how external temperature can control or influence the exertions of the workmen. In tracing the possible effects of humidity on output, it is admitted that the moisture content in the workshop differs very materially from that which obtains outside, and similar considerations should weigh in the case of temperature. A better test for determining the effect of outside temperature in the capacity for work would be afforded by the daily range, than by monthly or weekly averages. Between midday and midnight the temperature usually shows a greater change than between any two consecutive months, and often a much greater change. Consequently, a comparison between the output by day and by night would have offered a better means of testing the author's theory. Perhaps the data for such an inquiry do not exist, for though the method is alluded to, no arithmetical statistics are given. In one factory, the difference between summer and winter production is much larger than that quoted above, but as it is admitted that there was no artificial ventilation in this instance, the temperature in the neighbourhood of the furnaces must always have been considerably above that of the temperature outside. In two other cases, in which the same peculiarity is apparent, the data could not be standardised, and therefore do not carry the same weight. When, however, an arithmetic mean of the results from the five factories is taken, without weighting, the curve representing production certainly shows a seasonal variation, whatever be the cause. Separate curves for each of the five factories show very considerable variation, and it is to be feared that the less reliable results have aggravated the smaller variations shown by the more trustworthy data.

The evidence should be submitted to the closest scrutiny for the conclusions drawn are of the very highest importance. Not at all disturbed by the startling fact that the highest yearly output is shown to be from a factory where there is absolutely no artificial ventilation, and the maximum monthly record is held by the same factory, the author expresses his deliberate opinion that efficient ventilation is competent to increase the annual output of an unventilated mill house by 12 per cent. or more, and the statement published under the authority and with the sanction of an influential committee must carry such weight, that the slight qualification attached may pass unnoticed. It might be suggested as quite as probable that the slight seasonal variation actually demonstrated arises from lowered vitality and enervation of the workmen due to high temperature experienced generally.

In conclusion, Dr. Vernon offers some excellent suggestions calculated to improve the apparatus and to facilitate factory arrangements. With the view of reducing the weight lifted by manual labour, he proposes a reduction of the height from floor to furnace. The furnace floors, rolls, tank and doublers table might all be reduced in height, but as this alteration would entail more bending on the part of the workman, the determination of the most economical height is a matter for careful experiment. In the United States the rolls are several inches lower than in our mills, and this arrangement is said to carry two advantages: less weight lifting is necessary, and the men roll the iron with longer tongs. The sheet steel mills in this country have adopted various labour-saving devices which might be copied with advantage in the tin-plate industry. But the ingrained habit and conservative character of the working man would probably resent any innovation, however good the intent. Especially does Dr. Vernon fear that this adherence to custom would prevent any modification in the regulation dress, though upon medical and sanitary grounds some changes are recommended that should add to comfort and prove beneficial to health.

THE CESSION OF TSINGTAU TO JAPAN.

THE effect in the future of the creation of another Japanese sphere of influence, similar to Manchuria, is realised by all who are intimately connected with China, but it is perhaps as well that it should be more generally known on account of its indirect adverse effect on British trade, for the most probable consequence of this cession will be the decline of the port of Tientsin, the great port of North China, in which British interest predominates.

To indicate this probability it is only necessary to contrast the harbour and other facilities in the two ports. Tientsin is situated 36 miles from the sea on the banks of a narrow and, in spite of all improvements, tortuous river which has a bar at its mouth. As a result of this, in the spring and autumn vessels exceeding 12-ft. draught, and in May and June vessels drawing more than 14 ft., cannot reach Tientsin, but must, like all ocean-going vessels discharge at the bar into lighters. Further, on account of the narrow and winding waterway no vessel of over 300 ft. length can proceed to Tientsin, but must also discharge into lighters. Lastly, from December to March in most years and certainly for at least two months of that period the port of Tientsin is closed by ice.

When this occurs it is necessary to divert the trade of the port to the harbour of Chinwangtao, which is connected by rail with Tientsin. This, of course, entails additional transhipment and a journey of 180 miles for all goods, on a railway which is already sufficiently congested by lack of rolling-stock, a fact not making for prompt delivery.

With regard to facilities for discharge of cargo, vessels can lie alongside, but there are no appliances for handling heavy* cargo, nor is direct loading into railway trucks possible, as the only wharves on the railway side of the river are in private hands, with the result that cargo is stacked in the open if it is to be shipped by rail, as there appears to be little or no warehouse accommodation. All cargo is handled by coolie labour. Altogether there is about 7,000 ft. of wharfage for public use at Tientsin, while there are also wharves where cargo may discharge at the port of Tangku, about 27 miles below Tientsin. This port can be utilised when vessels cannot reach Tientsin either on account of ice or owing to excessive draught, but here again there is extra transhipment unless goods are sent by rail to the interior, for direct loading into cars is possible here. With regard to coaling vessels there is an unlimited supply of good coal here from the Kailan mines, situated about 80 miles distant. Coal is cheaper at Tangku than in any other port in China.

Railway facilities in Tientsin do not assist the transport problem for, as stated above, cargo must be unloaded by hand from the ship, then either warehoused or stacked in the open to wait until freight has been arranged when there is a further journey by road on hand carts hauled by coolies, of from 1 mile to 2 miles before reaching the railway. Once at the railway station, Tientsin is in an unequalled position as regards distribution by rail, for it lies at the parting of the ways for Peking, and thus the northern part of the district served by the Peking-Hankow Railway, and the lines serving the south and east, namely, the Tientsin-Pukow Railway serving the province of Shantung and the Peking-Mukden Railway serving Eastern Chihli, a province of Manchuria. Further through Tientsin must pass at present all seaborne goods for Shansi Province and Western Mongolia, *via* Peking and the Peking-Kalgan Railway.

The net value of the total trade of Tientsin exceeded 30,000,000*l.* in 1917, the bulk of this being in the hands of British firms, who have been established in the port longer than those of any other nationality. The total foreign population, excluding Japanese, is about 3,000, the majority of whom are British. Chinese population is estimated at 800,000. After Shanghai and Hong Kong, the port of Tientsin is the most important in China, and also one in which we are very largely interested from an investment point of view. Anything calculated to upset the existing order of things, such as deflection of trade routes, should be a matter of some concern. That this is possible the following short description of the facilities offered by the port of Tsingtau goes to show.

The port of Tsingtau lies roughly 400 miles by rail from Tientsin, and about 300 miles by sea, and is situated at the entrance to the enormous land-locked bay at Kiaochau, the entrance to which is not more than 1¾ miles wide. The port was occupied by Germany in November, 1897, following on the murder of two German missionaries by a Chinese mob, and the occupation was perpetuated shortly afterwards by a so-called lease for 99 years from China.

Germany did everything conceivable to develop the occupied territory, and also to exploit by every possible means the special rights acquired at the same time in the hinterland—the province of Shantung—with the result that the port of Tsingtau became a first-class naval base and, further, a considerable commercial port, with cargo-handling and other facilities infinitely superior to those at the port of Tientsin.

The harbour of Tsingtau is protected on the

* One or two private wharves have been opened.

north-east and west by a breakwater, and is sufficiently large to accommodate the shipping of the Far East. There is ample depth of water, and the largest vessels can come alongside at any state of the tide all the year round. The harbour is never closed by ice. The quayage totals 5,500 ft., of which 600 ft. is privately owned, and there is thus accommodation for about 12 vessels alongside. Cargo is discharged into and loaded from massive concrete warehouses built on the wharves and directly connected with the railways, and heavy articles can be loaded direct into trucks standing on the quays.

Under the Germans the quay warehouses, of which there are seven, were let to the shipping firms, and cargo could lie in them for 10 days free of charge. There are ample coaling facilities with coal supplied from German mines, in the province of Shantung. At present the trade of this port is rather more than one-third that of Tientsin. Of the Tsingtan trade, 87 per cent. is in the hands of Japanese, who have been in occupation since November, 1914. As usual, Japan has done everything possible to develop the place and to attract Japanese capital to the exclusion of all other for the development of the ex-German rights here and in the hinterland. It will thus be seen that as far as port facilities go Tientsin is not, and never can be, in a position to compete with Tsingtau, more especially with Tsingtau in the hands of the power which has closed the "open door" to trade in Manchuria.

Further, it is not only Tientsin's position as a port which is thus threatened, but also the advantages which its unequalled railway facilities give it, for the railway from Tsingtau to Tsinanfu is now under Japanese control. Now Tsinanfu, the capital of Shantung Province, is also on the trunk line from Tientsin to Pukow, and is now under the absolute control of China as regards the northern section of the line. If Japan adopts the Manchurian policy in dealing with her rights in this province it is very easily conceivable, in fact, more than probable, that the management of this line will eventually pass to Japan, in which case the policy of secret rebate and preferential rates for the port of Tsingtau will very quickly kill the Tientsin trade with this province. Further, one of the railway concessions now held, by Japan is for a line to connect Tsinanfu and thus Tsingtau with Shuntefu, on the Peking-Hankow Railway, which will provide a quicker route to the sea from Southern Chihli and the province of Shansi, and thus attract further trade now passing through Tientsin. This, of course, is a perfectly legitimate development, but the management of the northern section of the Tientsin-Pukow Railway should never be allowed to pass to Japan. China could, of course have efficiently protected herself against such a contingency by handing over the management of the line to the British, who already control the southern section of this line, but in part, probably as a result of Japanese machinations, she declined to adopt a course which would not only have safeguarded her from aggression, but would also have resulted in making this line a paying concern. Another scheme in which Japan jointly with an American corporation is interested, is the improvement of the Grand Canal within this province, a scheme which, of course, will be used to the utmost to promote trade through Tsingtau.

From the above it would appear that in acquiescing in the cession of German rights here to Japan, we have not only jeopardised the stability of our trade with North China, but have also presented Japan with further means for more efficiently competing with us, for we have also ceded the mineral rights in a province known to be rich in coal and iron commodities, of which there is great shortage in Japan. Moreover, these mineral rights have already been considerably developed by the Germans, thus the Shantung Mining Company, a German concern with a capital of nearly 1,000,000 had three collieries at various points on the Tsingtau-Tsinanfu Railway, which had an output in 1912 of 600,000 tons annually, and employed over 7,000 men. These are now being worked by Japan.

This summarises shortly the probable effects of Japanese control in Shantung, and it can only be said that such cession to a Power with Japan's record in Manchuria, and above all in Korea, is contrary to the principles on which is based the League of Nations. That we adopted our traditional and exasperating policy of *laissez faire* was only to be expected, but that America, the protector and friend of China, since 1904, subscribed to this arrangement is simply astounding. For both Powers everything was against cession—self-interest, sentiment which should not have allowed the sacred places of China to pass to an alien power, and right feeling which ought to have prevented ratification of an illegal bargain, and which was undoubtedly against the will of the people. For the first time, the masses in China have shown that a national feeling is developing. As a result of this national agitation the ministers responsible for the illegal Shantung agreement with Japan have been compelled to resign, and a very complete boycott of Japanese goods instituted. As a matter of course the cession of Tsingtau has not been calculated to enhance our already dwindling prestige in the Far East.

As regards Japan's foreign policy, the opinion is strongly held by those well acquainted with the facts that it is conducted on purely oriental lines. No better instance of this could be given than the Japanese handling of the recently promulgated Consortium agreement, by which the great Powers concerned in China's development are to provide and share the benefits of all future financial aid in China. This excellent scheme, which would ensure the future prosperity of China and end for ever the squabbles and undercutting, which characterised Far Eastern politics in pre-war days, is being officially subscribed to by Japan in Paris, but is at the same time being attacked in Peking by the official organ of the Japanese Legation in the hope of creating Chinese opposition to a scheme which it is alleged will endanger China's sovereignty.

NOTES.

Brightness of the Electric-Arc Crater.

It is fairly well agreed that the brightest spots of the positive-electrode crater have the temperature of the boiling point of carbon, and that the brightness is independent of the intensity of the arc-current. There are, however, divergent observations, notably those of Waidner and Burgess and of Lummer, according to whom the brightness may increase with the current intensity. This suggestion is confirmed by experiments described by E. Podszus in the *Verhandlungen der Deutschen Physikalischen Gesellschaft* of June last, and it is further suggested that the temperature of the crater must be higher than is usually assumed. The experiments were conducted in the Siemens works and with pure Siemens carbons. Podszus made his measurements by two methods—with a Kurlbaum-Holborn pyrometer provided with three reflecting prisms, and also with a König spectrophotometer closed in front by a ground-glass screen on which he observed the image of the crater. The arc was magnetically steadied, but it was not always easy to find the brightest part of the crater. The diameter of the carbons varied between 9 mm. and 25 mm., the arc length between 4 mm. and 48 mm., the volts between 14 and 100, and the amperes between 14 to 210. The maximum temperatures deduced ranged from 3,780 deg. C. to 4,090 deg. C. absolute. Currents of 150 amperes gave the highest temperatures, but these maximum temperatures were at times obtained with lower current intensities. The brilliancy of the crater was greatest with the steadiest arcs, though some investigators claim high temperatures for hissing arcs. Some of the observations of Podszus are peculiar, and it is manifest once more that the electric arc requires a good deal of further study. When the crater was very brilliant, the consumption of carbon was very rapid; the positive carbon seemed really to boil away at the rate of 10 mm. per minute, and a fine pointed projection developed in the crater. It is well known that the consumption of carbons changes with the atmosphere; the carbons burn away much faster in an open arc than in an enclosed arc, although air is not absent from the enclosed arc, and Podszus observed also a very rapid consumption of his carbons in an indifferent atmosphere of nitrogen. His account is not sufficiently detailed, however, and a previous paper of his, to which he refers, on steady filiform metallic vapour arcs, is, for some reason, not yet available in this country, although it was published in the *Zeitschrift für Elektrochemie* two years ago; the paper is only known by abstracts. To return to our subject, Podszus considers that in the ordinary arc the maximum possible temperature is only reached at a few points, if at all, because there are losses of heat by conduction and radiation, and the temperature does not rise above an equilibrium condition depending upon the current supply on the one hand and heat losses on the other. The arc may, he thinks, be at a higher temperature than the crater. But it is really high time that we had some more definite information about the arc in various gases and the supposed boiling of carbon, for which there is hardly any direct evidence. The carbon may simply combine with the gases of the atmosphere. The problems are difficult, no doubt, for they have certainly not been neglected.

The Structure of Colloids.

Some time ago we described how Debye and Scherrer had successfully applied Röntgen-ray examination to the study of the structure of crystalline and amorphous substances, in particular of graphite and amorphous carbon (Engineering, vol. civ., page 594). That this X-ray examination was not limited to the investigation of the structure of crystals had indeed been demonstrated by M. von Laue and his collaborators in their first original researches. In the "Nachrichten der Gesellschaft für Wissenshaften," Göttingen, of last year (available so far in abstract only) P. Scherrer has extended the method to the examination of the structure of colloids, both organic and inorganic. The colloidal particle may or may not have a crystalline structure. In the former case the X-ray examination should yield interference bands arranged in a manner characteristic of the space lattice; the positions of the bands would not depend upon the size of the particles, but the breadth of the bands would depend upon the size. In the latter case, in the absence of a crystalline structure, there would be no distinct bands, only one or several maxima of interference in the region of the incident ray, and the interpretation of the observations, always a matter of difficulty, would be more intricate. Examining colloidal gold and silver, Scherrer concludes that the particles are distinctly crystalline, and that they fit into the same space lattice as the macroscopic crystals similarly studied; the deduced sizes of the particles, moreover, agree with those determined by other methods, with the aid of the ultramicroscope or of osmotic pressure measurements. Even the smallest gold particles, no longer discernible by the ultramicroscope, seemed to have the same space lattice. The gels of silica (and also of stannic acid), former experiments had proved, undergo structural changes in the course of time; the aged specimens now examined show the characteristics both of amorphous and of crystalline particles, and in such gels crystallisation is evidently proceeding. Typical organic colloids, such as albumen, casein, gelatine, starch, cellulose, on the other hand, appear to be truly amorphous, and their colloidal particles probably consist of individual molecules or of groups of irregularly-orientated molecules.

Technical Men as Consuls.—A Consular examination will be held in the United States in the late autumn or early winter, says *Engineering and Mining Journal*, New York. It is the hope of officials at the State Department that a considerable number of technical men will take that examination. The Department recognises that the interests of the United States will be served best if technical men are available to fill vacancies in the Consular Service at points where their training will be of special value. For instance, a mining engineer would be considered especially for any vacancy at a foreign mining centre, and likewise a chemist would be considered for a centre of the chemical industry. The scale of pay in the Consular Service is so low that it is often difficult for a candidate, without other source of income, to maintain himself at the post to which he might be sent, and, in consequence, many young men well suited for consular work find such a career unattractive. For that reason as well as others, the Department would welcome as consular candidates technical men of means who would be willing to accept such service.

LITERATURE.

T.N.T., Trinitrotoluenes and Mono and Denitro Toluenes, their Manufacture and Properties. By G. Carlton Smith, B.S., Instructor in General Chemistry, Carnegie Institute of Technology, Pittsburgh, Pa. London: Constable and Co. [Price 8*s.* 6*d.* net, bound.]

The manufacturer of explosives will hardly consult this small octavo volume of 133 pages, which devotes 32 pages to the manufacture and purification of T.N.T. and is not illustrated. To the general reader and student the information on the history and theory of the nitration of toluene, on the inspection and testing of T.N.T.—a chapter contributed by Mr. K. K. Stevens—a fact which should have been pointed out in the preface—on the properties of the nitrotoluenes and on accidents in T.N.T. plants and T.N.T. diseases, will prove interesting, though the descriptions of processes are somewhat indefinite; it could hardly be otherwise in a book of so small a compass. For his data on the manufacture Mr. Smith acknowledges his indebtedness to Mr. R. W. Crawford, of the Grasselli Powder Company. It is customary to speak of three general T.N.T. processes, the one-stage, two-stage, and three-stage processes. In principle the three processes differ very little, and the distinction of one, two, three stages, is in a way misleading. For there are always three nitrations, but the three, or only one or two, may be performed with the same acid mixture and without separation of the several nitro-derivatives from one another and from the spent acid. The first nitration yields the mono-nitrotoluene. The further steps yield the di- and tri-products; but none of the reactions is limited to one product, and the final formation of the trinitrotoluene is never complete. All these products occur in several isomeric forms, moreover, more or less differing in properties, and the nitration may go beyond the intended limits and yield other products, notably phenylnitromethane, to which some medical men mainly attribute the poisonous effects of T.N.T.

In the one-stage process the same acid mixture, 75 per cent. of sulphuric acid and 25 per cent. of nitric acid, is used throughout, 1 kg. of toluene, which must be very pure, requiring 3 kg. of nitric acid and 9 kg. of sulphuric acid. The toluene is added to the acid mixture; the temperature is kept below 30 deg. C. for 2½ hours, and is then raised to 95 deg. by steam coils for 2 hours, after which cooking for 2 more hours at 120 deg. follows; then come the separating, washing and graining operations. Sulphuric acid always predominates in the acid mixture, and sulphonisation of toluene may possibly precede nitration in the reaction. In the two-stage process, which is favoured in Germany, less acid is used than in the one-stage, at 40 deg. and 60 deg. C.; the mono-product is separated by washing or distillation under reduced pressure, and then sulphonised (in sulphuric acid alone) and afterwards further nitrated in mixed acid at 120 deg. or (Langenscheidt's method) 140 deg. In the three-stage process, which predominates in America, though the others are also used, the second-stage yields dinitrotoluene, which is then centrifuged and sulphonated in the third-stage, in oleum at 100 deg. C. and further nitrated at 120 deg. This process requires least acid, which is important also because T.N.T. is by no means insoluble in the acid, but takes longer than the others. There is ample scope for variety of detail in each of the three processes, moreover, and the further operations are as important as the nitration. The T.N.T. formed is blown from the nitrator either with the acid or alone after cooling and separating in the nitrator; blowing means fusing the T.N.T. (melting point 80·6 deg. C.) and forcing it out by compressed air. Then follows washing with hot water and sodium sulphite which also neutralises residual acid; to neutralise by soda does not appear to be advisable because somewhat unstable sodium compounds are apt to be formed. For similar reasons traces of lead from the acid tanks in T.N.T. are dangerous because the product might subsequently be mixed with picric acid, which the presence of lead would make highly unsafe. The recovery of the spent acid—mainly sulphuric acid—is a very important problem.

There are six isomeric trinitrotoluenes, three of which have only been prepared within the last few years. T.N.T. proper is the symmetrical compound, of melting point 80·65 deg. C., which generally makes up about 98 per cent. of the good commercial explosive. It is certainly one of the safest war explosives, both in manufacture and use. Explosive decompositions by heat do not take place below 280 deg. C., but the T.N.T. is decomposed at lower temperatures. In some pre-war accidents heat did not cause explosion, notably not in the one at Schoenbeck in 1909, where a drum containing dry crystals of T.N.T. was hurled away by an explosion, apparently of alcohol vapour, and a wooden sieve containing T.N.T. was burned, both without exploding. Yet during 1918, Mr. C. Smith writes, 20 explosions and accidents occurred in the United States in T.N.T. works. The dangers of T.N.T. poisoning are not to be underrated either, though some medical men question the very prevalent belief that T.N.T. itself can be taken up through the skin. For the worker it does not much matter whether it is T.N.T. or some impurity which poisons him. Mr. Smith speaks of a Royal Society report on 181 cases of T.N.T. jaundice, 52 of which proved fatal. These figures are certainly unsatisfactory. In a minor way it is also unsatisfactory that Mr. Smith does not tell us what period and conditions those figures cover.

Both the index and the literature references of the book under notice are poor. "Annalen" is persistently misspelt "Anallen," and we are mostly given only volumes and pages, not dates, and in the case of the three patents referred to, numbers and dates, but no names. Yet the general reader, not in need of the more technical recent treatises on high explosives will find the book instructive.

Simple Interest Tables (£ *s. d.*). By William Schooling, C.B.E., F.R.A.S. London: Sir Isaac Pitman and Sons. [Price 2*1s.* net.]

The rule for the determination of the characteristics to attach to the logarithm of a number, in the form usually printed in tables, is so simple, that it is difficult to contrive a simpler, but for a special purpose it may be possible to dispense with any rule. Mr. Schooling makes the required simplification, by combining the characteristic with the mantissa and eliminating the decimal point altogether. Of course, this plan has the slight disadvantage that we have apparently a different logarithm for, say, 12, 120, &c., but since the tables are intended for the sole purpose of computing simple interest, this deviation from ordinary practice is of little consequence. This plan does not entirely remove the necessity for care with regard to the position of the decimal point, and special rules are framed to be used when the form of the computation is likely to lead to error. The object in view is, that the computer shall enjoy the advantages that logarithms possess without understanding the underlying principles in the same way "that one can switch on the electric light in ignorance of how it is produced." There is, of course, no difficulty in getting a satisfactory practical result. The work done is similar to that of a sliding scale, but we presume such a form, even if specially arranged for interest problems, would not be sufficiently exact. The accuracy aimed at here is that of the nearest penny.

Since interest is the continued product of principal, rate and time ($p\,r\,t$), it is easy with argument r to give the log. $r\,t \times \frac{240}{365}$, where t is the number of days in the interval and the factor $\frac{240}{365}$ is introduced in order that the result may be expressed in pence. Interpolation is altogether avoided, and all that is necessary is to add the number taken from the table to the log. of the principal, to have the answer directly. Simple as the operation is, it is, however necessary to enter three tables. First, to find the number of days elapsed between given dates, and here it may be said that the compiler does not consider the need of calculating, or exhibiting, the interest directly, for longer than a year. If the interval amounted to 500 days, for example, it would apparently be necessary to compute the interest for half the time and double the result. If the interest exceeds 100*l.*, other tables generally come into use; or, again, some of the factors may be divided and the final result increased in the same proportion. The second table may be called the "rate table," it gives the logs. of $r\,t$ when r is one of the ordinary rates of percentage, varying by steps of ½ per cent. If the interest is of an irregular amount, still another table has to be used. In any case the quantity taken from the "rate table" has to be added to the log. of the principal, taken from a third table. The interest is given in the same table, but at another opening. That the last result is exhibited in £ *s. d.* is a distinct advantage, but other tables are added, if need be, that express the interest as a decimal of a pound stirling and give the means for converting the decimal into shillings and pence.

It need hardly be said that the same tables will serve to compute r, or t, or p when the corresponding data are supplied. Also problems in "discounts" and "present value" can be worked out, though the computations are not quite so simple, and care has to be exercised lest the arithmetic goes wrong. We notice, too, that the author's example does not strictly accord with the table quoted. He has been obliged to suppress the characteristic without assigning any reason. There is, however, a page of explanation at the end which should make any doubts clear to ordinary intelligence.

It is well to point out that the great value of tables of this character lies in the fact that they proceed by regular and convenient steps, providing their own check upon accuracy. Any isolated calculation is liable to error, but that risk is greatly reduced and accuracy promoted when systematic computations are substituted. For convenience in use, much depends on typography and arrangement. In the volume now before us all such details appear to have been thought out very thoroughly. The tables are very clearly printed and explanations are given at the foot of each page. The accuracy is apparently all that can be desired, or reached with five-figure logarithms. These can hardly be relied upon to give five significant figures accurately, and that accuracy is needed if the third decimal place is to be trustworthy. In one of the examples, it is pointed out that the error or discrepancy amounts to 4*d.*, but this is an exceptional case. There are seven figures in the number and the log. given to only five, is manifestly inadequate. It would be regrettable if any one reading the introduction should think that this example is in any sense a fair measure of the general accuracy of the work.

Petrol and Petroleum Spirits: A Description of their Sources, Preparation, Examination and Uses. By Wilfred E. Guttentag, Captain R.A.F., with a Preface by Sir John Cadman, K.C.M.G. London: Edwin Arnold, 1918. [Price 10*s.* 6*d.* net.]

The number of works on Petroleum Technology or some section of this wide subject has increased enormously of late. Sir Boverton Redwood's "Treatise on Petroleum" remains the standard authority, but it is rather a forbidding work for those who are in need of some definite information on a particular point. Several authors of practical experience, in one or other branch of petrol technics, have sought to assist the inquirer who has to deal with petroleum products. Captain Guttentag is one of the latest to set forth a description of the sources, preparation, refining and examination of petrol, that shall be sufficiently exact but free from the minute details that perplex, rather than inform, the uninstructed, in quest of a rapid result. Sir John Cadman, in a foreword, recommends this work to the student and the field chemist "to whom it will surely prove invaluable." It would be impertinent to add anything to this recommendation, but we may say that we believe that those who are aware that petrol has a wide range of physical conditions, and wish to purchase a spirit that is best adapted for the purpose to which it is to be applied, will find here an adequate guide through the many pitfalls that ignorance or self-interest on the part of tradesmen prepares for the unwary consumer.

The blessed word "specific gravity," which has been used to silence so many complaints is fast losing its value as a charm to lull the suspicions of a long-suffering public, who is becoming aware that this criterion of quality varies according to source and method of preparation. In the future,

uniformity of composition will be demanded with greater insistance than in the past, and the practice of blending high and low-boiling products will stand condemned. The author gives a form of specification that indicates the desirable products that a motor spirit should possess, and which it is judicious to demand. Such a specification, modelled on recommendations from the United States Bureau of Mines, is well worthy of study, and if the reader grasps the reasons for each of the requirements insisted upon, he will not be entirely at the mercy of the petrol merchant.

Motor fuel is treated much in the same way, but herein "cracked" spirit finds greater application, and a charge is brought against its use which we trust will not be substantiated, for the process of "cracking" promises to increase the economic value of the stores of petroleum and to prolong the life of the oilfields. Cracked products, the results of converting paraffins and naphthenes by dissociation into other hydrocarbons of lower boiling-point or higher volatility, are stated to contain large quantities of unsaturated hydrocarbons, which, during storage, or use, may induce a polymerisation which furnishes an indifferent product. It is admitted, however, that though such lower boiling-point products have been extensively used in America, "no complaints have been heard as to their damaging effects in engines." In another place, we read that cracking leads to the production of resinous bodies which are soluble in the spirit, and that "these bodies render the spirit unfit for use as motor fuel, and have given "cracked" spirits generally a bad reputation." It is difficult to reconcile these two statements, but the latter may apply to aviation machines, and the book being written in war time fuller explanation was not desirable.

If some doubt overhangs the merits of "cracked" spirit in motor fuel, the author expresses himself with no uncertain voice on the inoffensive nature of sulphur, and we believe he will carry the general opinion with him, though it has been usual to attribute to sulphur many inconveniences which could not be traced to more legitimate sources. The author maintains that the corrosive action of sulphur, contained in petrol, has been greatly exaggerated. Particularly is this charge indefensible in the parts of the machine maintained at high temperature, and so sure is he of his ground, that he declines to discuss the contention at any great length. The point is of some importance, for as Captain Guttentag reminds us, with the increased demand for petrol owing to the improvements in motor vehicles and the probable construction of an extensive fleet of commercial aeroplanes, some strange substitutes of unknown constitution are likely to come on the market. It is important, therefore, to know what ingredients are injurious and what may be tolerated.

The chapters on the refining of crude oil, on fractional distillation, and the description of the processes of rectification to concentrate fractions within definite specific gravities are short, but readable. The author has not attempted a handbook for the technological expert, but rather for those who have to utilise the finished product. The early treatment of the crude oils is therefore not discussed in greater detail than is necessary to make intelligible those processes, which may effect its subsequent practical use.

BOOKS RECEIVED.

Aeroplane Timbers: their Structure, Formation and Mechanical and Commercial Properties. By Gilbert R. Keen. London: William Rider and Son, Limited. [Price 6s. net.]

Molecular Physics. By James Arthur Crowther, Sc.D. Second Edition. London: J. and A. Churchill. Price 6s. net.]

Report of the Committee for Scientific and Industrial Research for the Year 1918–19. London: His Majesty's Stationery Office. [Price 6d. net.]

Anuario de Mineria, Metalurgia, Electricidad y Dernas Industrias de España. Ano 1919. Bajo la Direccion de Don Adriano Contreras, Don Roman Oriol y Don Luis Oriol. Madrid: Grafica Excelsior, Campomanes, 6. [Price 8,50 pesetas.]

La Probabilité dans les Tirs de Guerre. Par Jean Aubert. Paris: Gauthiers-Villars et Cie. [Price 6 francs.]

Telemetrica, per Pratica e per Studio. Giuseppe del Fabrio. Milan: Ubrico Hoepli. [Price 13·50 lire.]

THE LATE SIR CHARLES E. H. CHADWYCK-HEALEY, BART.

We regret to learn of the death on the 5th instant, after a short illness, of Captain Sir Charles Edward Heley Chadwyck-Healey, Bart., K.C.B., K.C., R.N.R., who was the senior proprietor of our contemporary, "*The Engineer.*" He was born on August 26, 1845, and was the only son of the late Mr. Edward Chas. Healey, of Wyphurst, Cranley, Surrey. He adopted the law as a profession, becoming a bencher of Lincoln's Inn, and being called to the Bar in 1872. He quickly established a reputation as a junior counsel in the Chancery Court, and was admitted to silk in 1890. The sea, however, had great attraction for him, and, retiring from the Bar in 1893, he found great enjoyment and full satisfaction in strenuous work of this nature. He had been one of the earliest of the Royal Naval Artillery Volunteers, and had advanced to the rank of Commander of a Battery, while from 1889 he was an officer in Royal Naval Reserve. He was a strong advocate of the fullest possible support of the proposal to create a Reserve for the Royal Navy, and formulated proposals for this purpose which were carefully considered by the Grey Committee in 1902, with the result that in 1903, the "Naval Forces Act" was passed, and the Royal Naval Volunteer Reserve came into being. He was appointed chairman of the administrative body of the "Admiralty Volunteer Committee" at its inception, and remained such until April, 1914, when he retired, to give younger men a chance of promotion. At the beginning of the war, however, he quickly found his most fitting place in the Navy Service, as he took over the small hospital ship, the Queen Alexandra, which had been offered by the Royal Mission for Deep Sea Fishermen, for service with the Fleet. Not only did he command her, but met all the costs until she was discharged from the Fleet in the early months of 1919. He was also a member of the Admiralty Transport Arbitration Board from 1914, his legal training making him most effective as one of Admiralty arbitrators on that Board. Sir Charles took a great part in the administration and social life in the counties of Surrey and Somerset, in both of which he owned property. He was not only a J.P. of the county of Surrey but Chairman of the Quarter Sessions, and Deputy Lieutenant and a County Alderman of the county of Somerset, and served as High Sheriff of that county in 1911-1912. He was at one time Chancellor of the dioceses of Salisbury, Exeter and Bath and Wells. He also served on several Royal Commissions. He was married twice: first, in 1872, to Rosa, daughter of the late John Clowes, of York, and, secondly, in 1884, to Frances, daughter of the late W. Killigrew Wait, formerly Member of Parliament for the city of Gloucester. He was created a Companion of the Bath in 1905 and a Knight Commander of the same Order in 1909. This year the dignity of a baronetcy was conferred upon him. His heir is his son, Mr. Gerald Chadwyck-Healey, C.B.E., who became Director of Materials and Priority at the Admiralty, in succession to Sir Robert Horne, when the latter became Third Civil Lord.

INDUSTRIAL NOTES.

A settlement in the railway strike was arrived at last Sunday afternoon, and in the course of the evening a statement to the following effect was issued:—

"The representatives of the railwaymen's unions, accompanied by the representatives of the Transport Workers and Associated Unions, called at 10, Downing-street at 11.30 a.m to-day, and had interviews with the Prime Minister and Mr. Bonar Law. As a result the following agreement was reached:—

"1. Work to be resumed forthwith.

"2. On the full resumption of work, negotiations shall be continued with the understanding that they will be completed before December 31, 1919.

"3. Wages will be stabilised in the United Kingdom at their present level up to September 30, 1920; any time after August 1, 1920, they may be reviewed in the light of the circumstances then existing.

"4. No adult railwaymen in Great Britain shall receive less than 51*s.* so long as the cost of living is not less than 110 per cent. above pre-war level.

"5. The National Union of Railwaymen and the Amalgamated Society of Locomotive Engineers and Firemen agree that the men shall work harmoniously with the railway servants who have remained at or returned to work, and the Government and the National Union of Railwaymen, and the Amalgamated Society of Locomotive Enginemen and Firemen agree that no man shall be prejudiced in any way as a result of the strike.

"6. The arrears of wages which have been withheld in consequence of breach of contract will be paid after the resumption of work."

From various quarters, says *Engineering News-Record*, New York, comes word that Germany is settling down to its industrial work quicker than any other of the warring nations. Lieutenant-Colonel F. H. Wagner, recently returned from Germany, stated in an address in Baltimore: "Germany is to-day the sanest nation in Europe. Except in a few isolated places, there are no strikes. They are quietly preparing to flood the world with cheap goods. The German workmen are working 11 hours a day for 8 hours' pay. In France, the workmen are working 3 hours a day for 8 hours' pay." This general view, adds our American contemporary, is borne out by a report from Mr. G. Renwick, the English correspondent, on his return to Germany a few weeks ago after an absence of two months. "The most striking change," he says, in a cable message to the *New York Times*, "is undoubtedly the noteworthy evidence of greatly increased and increasing industrial productivity, while there is also, I believe, a much saner spirit throughout the country. The country is getting busier every day. On all hands, one sees evidence that Germany is putting her shoulder ever more determinedly to the deeply rutted wheel." He then describes the great quantity and variety of goods at low cost found for sale in the shops, and contrasts that condition with the scarcity of two months ago. The *News-Record* says it has no desire to go back to the popular pre-war habit of holding up Germany as a model, but, it adds, we can learn something from the way the Germans are increasing production.

It, further, contrasts with the spirit in Germany the action of the United Mine Workers of America. A few weeks ago, the latter declared not merely for nationalisation of the coal mines, but for a 6-hour day and a 5-day week. That way, it concludes, lie starvation and industrial wreckage, unless during the actual working period efficiency is tremendously increased. The spirit of the times, though, gives no hope for increased efficiency.

The situation is confirmed as regards this country by news emanating from a firm in Patricroft. This firm having stated their inability to deliver goods according to promise to Holland, their agents in Rotterdam, Messrs. Wynmalen & H. Mann, replied stating that this inability to supply upset all the plans of the Dutch customers and created a feeling against the British manufacturers. The agents added that they would like to shout from the housetops that the British workmen were spoiling every bit of the results of the war; if the British workmen believed that with strikes, short hours and all other nonsense they would be able to compete against the Huns, they were mistaken. The Huns, the Rotterdam agents added, were working now like devils to win the war which they had lost with their arms, and they had a good chance to succeed. As a result, the British workmen will be absolutely cut out and the world flooded with German stuff. Then it will be too late. Customers will not look at British-made goods because they are too dear and because they cannot rely upon deliveries. If the British people only knew what the Huns are doing, if they saw the enormous quantities of machinery they are already importing into Holland, they would at once stop their nonsensical actions and start to work, not only in their own interest but in that of the whole world.

Speaking last week at the fifty-fourth annual meeting of the shareholders of Bolckow, Vaughan and Co., Limited, the chairman, Sir J. E. Johnson-Ferguson, Bart., dealing with the Coal Commission, said the housing question had no right at all to have been brought up before the Commission; it was not included in the questions referred to it. During the ten years preceding the war his company had erected 1,100 new houses at a cost of over 200,000*l.*, all of which compared favourably with the houses built in recent years by the operatives in Lancashire towns. Section B of the interim report recommended that the coalowners should be allowed to retain only 1*s.* 2*d.* per ton on the coal raised. The exact meaning of that provision seemed doubtful, but if it became law he thought it very questionable indeed whether any fresh collieries would be sunk unless under exceptional circumstances. The nationalisation of the mines would be in his opinion one of the most disastrous steps that the country had ever taken. Not only would nationalisation ruin the coal industry, but by destroying the greatest incentive to improvement and development, the steel trade of the country would also soon be strangled. Further, Section 39 says: "Without prejudice to the powers recommended in the last paragraph, it is a matter of careful consideration whether the coke and by-product industry, which at present is only in its infancy, should not be allowed to remain in private ownership." If that means anything at all, said the speaker, it means that because the by-product industry is being rapidly developed and new discoveries applied to it, the owners are not to be disturbed until they have developed the

industry to the fullest extent, when at once they are to be deprived of the benefit of their capital and skill. Could, he added, a more cynical and flagrant piece of robbery be put forward?

The annual meeting of Messrs. John Brown and Co., Limited, was held in Sheffield on Monday, September 29. In the absence of Lord Aberconway, Sir Charles Ellis presided. In the course of his speech, he said he had seen it stated by miners' representatives that owners were deliberately, for their own purpose, keeping down the output of coal. A more astounding or untrue allegation had never been put forward. To anyone who knew anything at all about collieries, it was so obvious that every extra ton of coal produced would bear its share of the huge general charges which must go on whether the colliery was working or not, that the allegation carried its own refutation. He referred to the company's acquisition of interests in the Carnforth Hematite Iron Company and in the Craven Railway Carriage and Wagon Company, the former to ensure a supply of first-class hematite pig-iron and the latter as a means of ensuring a friendly customer for much of the company's production in railway material. In regard to the Coventry Ordnance Works, they were concerned with armaments, and these could not be continued under existing conditions. The company had therefore arranged to join forces with large electrical machinery producers and had formed themselves into the English Electric Company, Limited, which would be capable of dealing with every class of electrical installation.

Speaking on Tuesday, September 30, at the ordinary meeting in London, of Messrs. John Lysaght, Limited, Mr. H. Seymour Berry, the chairman, referred to the change which had taken place in the company, and to which we alluded on page 349 *ante*. He explained that the change was the following: He, in conjunction with his friends, had acquired the holding of the trustees of the late John Lysaght, representing all but a very small percentage of the ordinary capital, and the three members of the Board who sat in the capacity of trustees for those shares had retired as a consequence of the sale. They retained all four of what he might describe as the working members of the Board of John Lysaght. At their headquarters, St. Vincent Works, and Nethan Works, Bristol, they had Mr. S. R. Lysaght and Mr. H. G. Hill. In charge of Newport there will be in future, as in the past, Mr. W. R. Lysaght and Mr. D. C. Lysaght. In Australia, Mr. H. R. Lysaght will continue to act as general manager. One of the most satisfactory features of the business, added Mr. Berry, lies in the fact that the operations of the company include every process required in the manufacture of its chief productions, commencing with the mining of the iron ore at Scunthorpe and ending with the distribution of their output in the markets at home and abroad. Being independent of outside purchases of raw material, uniformity in quality is obtained and the continued excellence of the brands is assured. The company's organisations in Australia, New Zealand, South Africa, Canada and South America, in all of which places the company have their own establishments, managers and staff, give special facilities for distribution, and make possible a regularity of output and export which is independent of the immediate market conditions or reliance on orders from export merchants. The company have commenced the erection of their own works at Newcastle, N.S.W., for sheet rolling and galvanising.

Very interesting remarks concerning British shipping were made by Sir Frederick W. Lewis, Bart., in the course of the speech which he delivered on Thursday, the 2nd inst., at the twenty-eighth annual meeting of Messrs. Furness, Withy and Co., Limited. Sir Frederick stated that: ". . . Judging from an announcement made a little while ago, all the obvious arguments against the nationalisation of shipping seem to have been accepted by the Government. Under Government control costs would be greater than under private management, with the result that to make ends meet we would have higher, rather than lower, freights, and it would be a very grave matter lightly to undertake the burden of nationalising the British mercantile marine—a venture which I calculate would involve an outlay of approximately 600,000,000*l.* to 700,000,000*l.* for ships alone, altogether apart from all the ancillary assets which go to make up a great steamship organisation. This is a sum nearly equal to the National Debt before the war. But for the private enterprise of British shipowners in the building up of a great merchant marine service, built up in the face of restrictions and hardships which did not apply to foreigners, this country would now in all probability be under German rule. In the past, Great Britain has only been allowed to do the carrying trade of the world because she has done it better and more efficiently than anybody else. It does not require any very great stretch of imagination to form some idea of the effect of the competition of private shipowners of other nations upon the nationalised shipping of the British Government.

"Whilst I do not wish to minimise the serious competition we will have to face, I am not by any means doubtful of the ability of British shipping to hold its own, always providing freedom of control is allowed, but if Government Departments are going to continue the policy of purchasing great masses of material, dumping it on our quays and docks irrespective of the capacity of the country to receive it; if the wharves and transit sheds are to be used as warehouses for these goods; and if steamers are not going to be allowed to take their bunker requirements at the natural bunker centres, but are to be made to waste time in unnecessary removal to other parts for these supplies; if bunker coal is not going to be released as required for the merchant marine; if vessels are to wait 20 and 30 days for their coal requirements; if employers are not going to realise the new spirit of the times; if Labour is not going to give of its best and increase the production of the country; then I will not be able to stand here very many more times and utter words of hope and encouragement in regard to the future of our industry. But somehow or other I have confidence in the ultimate common sense of all sections of the community, and, notwithstanding the dark outlook at the present time, I have little doubt but that we will be able to hold our own and play our part in the restoration of the solid foundations of commerce. . . ."

The twentieth ordinary general meeting of the Associated Portland Cement Manufacturers (1900), Limited, took place on the 3rd inst., when the chairman, Brigadier-General the Hon. F. C. Stanley, C.M.G., D.S.O., said he was glad to state that the formation of a Whitley Council for the cement trade was well advanced. The Ministry of Labour, the Cement Makers' Federation, and the chief unions involved were co-operating for this purpose. "We all welcome," he added, "the improved organisation of labour, and are confident that the better opportunities now afforded for exchange of views will lead to a more complete understanding and easier solution of the difficulties both of employers and employees. We recognise that the workers' pre-war standard of comfort and conditions of living needed improvement, and we agreed, in conjunction with the rest of the trade, in March last, to a 48-hours' working week and the granting of a full week's holiday with full pay to all employees of a year's standing, and a week's holiday with pay at a lower rate even to those who have been with us for six months. I might add that these arrangements were made at a time when the shortage of labour was most acute, and when to lessen hours needed some courage, but we were determined to face the difficulties which the granting of the shortened hours involved, being convinced of the justice of the workers' demands in this respect. It is, however, essential that we should now settle down and all work to obtain increased production which is needed to put our industry on a sound basis, and, indeed, to ensure that national prosperity which is essential to our recovery from the ravages of war. I do not think any further shortening of hours in the cement industry practicable under present conditions, and in saying this I am not unmindful of the necessity for employers maintaining a wide outlook and sympathetic attitude towards the improved conditions to which labour is entitled, and to an increased share in its prosperity, which can only be obtained by increased production. . . ."

ELECTRIC POWER IN THE UNITED STATES.—According to the United States Geological Survey, electric-power plants in the United States engaged in public service, including central stations, electric railways and various other plants, supplied in March last, a daily average of 101,400,000 kw.-hours. Of this amount, 41 per cent. was produced by water power. In the plants using coal, the average consumption per kw.-hour was 3 lb. These figures were based on 3,075 reports, from 89 per cent. of the public service plants.

THE PAY OF CONSTRUCTORS AND OF DESIGNERS.—Should engineers engaged in construction be paid more than those engaged in design, asks *Engineering News Record*, New York. That question is raised by a recent tentative schedule of salaries for highway engineers. Those in charge of construction were to be paid more than those who designed and maintained the self-same roads and bridges. Is this as it should be? Does it require more ability and experience to build a given job than to design it? Can maintenance of a system of highways be left to men of lower calibre than those who build it? Our American contemporary concludes by asking whether less talent is required for bridge designing than for the construction of bridges and highways.

THE MICRO-MECHANISM OF THE AGEING OF DURALUMIN.*

By ZAY JEFFRIES, D.Sc., Member (Cleveland, Ohio, U.S.A.).

IT is well known that certain aluminium base alloys containing up to 4 per cent. copper, and up to 1 per cent. magnesium, can have their properties changed by heat treatment, the most unusual feature being that of the change of properties of the alloy at room temperature, after quenching. An alloy containing, say, 3 per cent. copper and 0·5 per cent. magnesium, and the balance aluminium, after being rolled into sheet form, or after extrusion, may have its properties changed materially by heat treatment. When heated to 500 deg. and quenched in water the metal is relatively soft, and if allowed to remain at room temperature, it increases in hardness and strength, gradually, for four or five days. This phenomenon was first studied by Alfred Wilm.†

Recently, Merica, Waltenberg and Scott‡ have presented a paper on the heat treatment of duralumin, which greatly increases our knowledge on this subject. Below are enumerated observations and conclusions concerning the heat treatment of duralumin, in general agreement with the ideas put forth by the above authors, and other investigations. The present author has had experience with all the observations, except the absence of ageing in liquid air and the thermal critical point, which are reported by Merica, Waltenberg and Scott.

1. Copper, probably as $CuAl_2$, is soluble in solid aluminium at 500 deg. to the extent of about 3 per cent. In cooling to 300 deg. the solubility is reduced to about 1 per cent., and is still further reduced on cooling to room temperature.

2. When a saturated solution of $CuAl_2$ in aluminium, is cooled from 500 deg., the excess $CuAl_2$ precipitates. The distribution of the precipitated $CuAl_2$ depends on the rate of cooling; slow cooling promotes the formation of relatively large particles, and fast cooling promotes a high degree of dispersion. The physical properties change with the rate of cooling, in general, the slower rates producing the softer, weaker material.

3. When a solution like the above (2) is cooled from 500 deg. to ordinary temperatures very slowly, no change in physical properties takes place on ageing at room temperature. When the rate of cooling is rapid, however, the physical properties change at ordinary temperatures. The tensile strength and elastic limit increase, and the elongation decreases, the ageing effect being nearly completed after about 100 hours. The hardness increases on ageing, as would be expected from the changes in tensile properties.

4. The addition to the above (2) of ¼ per cent. magnesium, with or without small quantities of other elements like manganese, only affects the magnitude of the changes in properties in the various stages of heat treatment. For the purposes of this Note, therefore, these elements need not be further considered.

5. An aluminium alloy containing about 3 per cent. copper is not in the softest possible condition immediately after quenching from 500 deg. If furnace-cooled from this temperature it is both softer and weaker than immediately after quenching.

6. If the above alloy is cooled and allowed to remain at the temperature of liquid air, immediately after quenching, no ageing effect takes place. If heated above ordinary temperature the ageing becomes more rapid, and the final properties after extended ageing, are different from those obtained by room temperature ageing. If aged at 200 deg. the hardness, as measured at room temperature, increases to a degree never reached in ordinary ageing (at least for a period of months), and then it decreases with further extension of the ageing time. Ageing, even at room temperature, must be considered as a prolonged heat treatment of the material. If our atmospheric temperature were the same as that of boiling liquid air we should have to heat duralumin to produce any change in properties.

7. When duralumin is quenched from 500 deg., and immediately heated, an evolution of heat occurs at about 260 deg. If aged to maximum hardness at 100 deg. to 150 deg. and then heated, this heat evolution does not take place. If the sample is initially slowly cooled from 500 deg. no heat evolution occurs on heating.

8. The fracture of duralumin quenched from 500 deg., broken in tension, is intra-crystalline, both before and after ageing. When the copper content exceeds 4 per cent. a network of $CuAl_2$ is sometimes present, which promotes fractures of the cell boundaries, but in normal duralumin the fracture is through the grains.

9. So far as is known aluminium undergoes no allotropic changes between ordinary temperature and its melting point.

10. From the above considerations, Merica, Waltenberg and Scott conclude that there is a certain average size of precipitated $CuAl_2$ particle which produces maximum strength and hardness in duralumin; that when the size of particle is less than this particular size, or larger than this size, the hardness decreases. The present author agrees with this conclusion, because it seems to be directly indicated by the facts; he agrees notwithstanding the abundant evidence with other non-allotropic metals, that maximum dispersion produces maximum hardness, even to atomic dispersion, that is, solid solution.

Why does duralumin present this apparent discrepancy?

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* Paper contributed to the Institute of Metals, September 25, 1919.

† *Metallurgie*, 1911, p. 225.

‡ *Bulletin of the American Institute of Mining and Metallurgical Engineers*, June, 1919, p. 913.

The author offers the following as an explanation of the above observations.

Let us first consider some physical aspects of the precipitation of $CuAl_2$ from a saturated solution on cooling. When a molecule of $CuAl_2$ is removed from the solvent, or matrix, and added to another group of $CuAl_2$ molecules, as is known to occur on slow cooling, the forces of adhesion between the $CuAl_2$ molecule and the solvent have been exceeded. Since a change in temperature only is sufficient to cause precipitation, it must also be sufficient to cause the loss of adhesion bonds between the excess $CuAl_2$ molecules and the solvent, or matrix. Lost adhesion bonds means loss of cohesion of the mass as a whole. This idea occurs with the theory that mechanical cohesion is only a manifestation of the internal valence forces, both primary and secondary.*

When duralumin is cooled from 500 deg. in a furnace globules of $CuAl_2$, large enough to be seen easily with a high-power microscope, are formed. In the same sample, however, some globules are so small as to be hardly distinguishable, and others too small to be resolved are suggested by the non-uniformity of the surface appearance of the section. When it is considered that the smallest globule of $CuAl_2$ resolvable with a high-power microscope contains about 2,000,000,000 molecules, it is evident that with rapid cooling sub-microscopic particles of $CuAl_2$ must be present in large numbers; in fact, after quenching, the average size of particle must be sub-microscopic. The whole phenomenon of ageing must therefore involve changes which cannot be studied directly with a microscope.

We must also accept the proposition that the change in properties on ageing are due to molecular changes within the metal; that those molecular rearrangements are not possible in liquid air; that they take place slowly at ordinary temperature and more rapidly as the temperature is increased. We can visualise these molecular rearrangements best by assuming that the precipitation of $CuAl_2$, and segregation into particles, are two distinct steps. Immediately after quenching duralumin some 500 deg. the excess $CuAl_2$ is thus considered to be precipitated; some of it will have formed into small particles and some will be precipitated as single molecules which have little or no adhesion with the particles of the matrix. This condition produces the low mechanical cohesion observed in duralumin after quenching and before ageing. The increase in cohesion of the whole mass could be brought about by the agglomeration of these precipitated molecules of $CuAl_2$. In the first place the particles of the matrix would establish cohesion bonds with one another in the space formerly occupied by a $CuAl_2$ molecule. This would increase the cohesion of the matrix. Then the small globule, made up of many $CuAl_2$ molecules, would acquire its own specific cohesion.

Having thus produced increased cohesion of the matrix and the $CuAl_2$ particles, we have only to account for a strong adhesive bond between these to account for the observed increased cohesion or hardness of aged duralumin.

It will be remembered that some $CuAl_2$ is soluble in the matrix at room temperature, and, therefore, it is only the excess that can form into minute globules. The presence of a globule of $CuAl_2$ acts as a centre of crystallization, and hence easily attracts to itself the adjacent excess $CuAl_2$ molecules in the matrix, and impoverishes the matrix at the boundary. This accomplishes two things, namely, it facilitates migration of $CuAl_2$ towards the globule by the forces of diffusion, and it reduces the number of $CuAl_2$ molecules in the matrix at the boundary with the globule to normal saturation, which is the condition for maximum adhesion between $CuAl_2$ and the matrix. Thus the strong adhesion bond between these two substances is established. It is probable that the concentration of a saturated solution of $CuAl_2$ in aluminium in the absence of $CuAl_2$ nuclei is greater than when these nuclei are present. It is also probable that the actual boundary between a $CuAl_2$ particle and the matrix is an amorphous solution of $CuAl_2$ in aluminium.

According to the above, the reason that maximum diffusion does not produce maximum cohesion is that the adhesion bonds between the excess $CuAl_2$ molecules and the matrix are not strong, and the spaces which they occupy might act as voids in affecting cohesion. Ageing removes the voids from the matrix, thus increasing its cohesion; it establishes cohesion in the newly formed $CuAl_2$ globules, and adhesion between these and the matrix. If the particles of $CuAl_2$ continue to increase in size beyond a certain average and decrease in number, as in prolonged ageing, at 200 deg., the cohesion decreases.

The formation of cohesion and adhesion bonds between the atoms and molecules in duralumin at room temperatures might be questioned. If we press two pieces together and allow them to remain at ordinary temperatures for long periods of time we cannot produce such results. No doubt the absorption phenomenon militates against this low temperature welding,† as does also unclean surfaces due to oxidation. The formation of cohesive masses of metal at ordinary temperature by electro-deposition teaches us that high temperature is not necessary for the formation of cohesive bonds. The interior of a mass of duralumin should be free from adsorption and oxidation, and hence the atoms and molecules would be free to form bonds with one another at temperatures much below that of welding. It should be kept in mind that welding is accomplished at high temperatures in spite of the retarding influences of adsorption and oxidation.

The heat evolution observed at about 260 deg. might well be due to a rapid crystallization of $CuAl_2$ rather than the mere precipitation. The fact that rupture takes place through the grains is evidence that, whatever changes go on within the alloy, those which affect the physical properties must be intra-crystalline.

Other alloys will, no doubt, show similar changes in properties when studied in the proper temperature range. Future investigations of alloys at various temperatures must form the basis for a more complete and modified interpretation of the new and old facts observed in connection with the phenomenon called ageing. Quantitative evidence must be introduced as soon as facts permit. Ageing experiments on duralumin extending over a period of many years will be interesting with respect to the relations between the changes in properties and the engineering uses. It is obvious that the material cannot be used at 200 deg. for a long time without changing markedly in properties. What is the maximum temperature which will permit so little change on extended ageing of duralumin that it may be used with safety at that temperature?

A study of this question is necessary in order to change the specific composition and heat treatment of the alloy to meet certain engineering requirements. The author and Mr. R. S. Archer are preparing a paper on the general subject of the heat treatment of aluminium base alloy which will discuss these questions in more detail.

*Langmuir, *Journal of the American Chemical Society*, 1916, vol. xxxviii, p. 2221; 1917, vol xxxix. p. 1848; 1919, vol xli. p. 868.

† Langmuir, *Journal of the American Chemical Society*, 1916, vol. xxxviii, p. 2221; 1917, vol. xxxix, p. 1848; 1919, vol. xli, p. 868.

THE SIX-STRING EINTHOVEN GALVANOMETER.

To the Editor of Engineering.

Sir,—In your description of the six-string Einthoven galvanometer, published in Engineering for August 22, justice has not been done to the actual inventor of this form of the apparatus. As stated in your article, Professor Einthoven invented the instruments for use in his physiological researches. A great number of other workers followed in his footsteps, and in connection with the study of heart sounds the need was found for a second string to the galvanometer. This need was met by the invention by Mr. W. H. Apthorpe of the double fibre holder and double prism, so that two strings were mounted in the same magnetic field. This invention was covered by patent No. 20654, A.D. 1913, and was also described in the Proceedings of the Physical Society of London, 1914, vol. xxvi, page 314. When special work for which the six-string galvanometer was required arose Mr. Bull, of the Institut Marey, Paris, was asked by the French authorities to co-operate. Mr. Bull is well-known in connection with his physiological researches in which he has employed the string galvanometer. He designed the six-string galvanometer practically as it stands at the present day, and as illustrated in your Fig. 4. During the war many instruments were made under his supervision in Paris. Owing to the increasing demand for apparatus of this type, the Cambridge Scientific Instrument Company was asked to co-operate in their manufacture, and modified the instrument in various details, but the firm do not claim the credit of having invented the apparatus.

Yours faithfully,
For The Cambridge Scientific Instrument Company, Limited,
Horace Darwin, Chairman.

Cambridge, England, September 26, 1919.

UNIVERSITY MATHEMATICS FOR ENGINEERS.

To the Editor of Engineering.

Sir,—I propose that this shall be my last word in the present discussion, unless the university professors have something to say in defence of their teaching. I have written privately to each of the universities in question, drawing attention to the way in which they have been referred to in my published letters.

Mr. Hughes wants to know what objections I have to advance against his treatment of the hyperbolic functions, which I understand is a repetition or slight modification of Mr. Edser's. My reply is that the argument is unnecessarily difficult, and the conclusion not so correct as the one that I arrive at in the following comparatively simple manner.

I begin by pointing out that cos V and sin V might have been defined as the rectangular co-ordinates of points on a circle of unit radius; and I accordingly define cosh V and sinh V as the rectangular co-ordinates of points on the right-hand half of the corresponding hyperbola (meaning the rectangular hyperbola whose semi-axis is the radius of this circle).

I then prove, in the manner explained in your issue dated August 15, that the V in the above expressions is numerically equal to twice the area of the corresponding sector (circular or hyperbolic as the case may be); and, as an easy corollary from this, I get the final result,

$$V = \int_0^\theta r^2 . d\theta, \text{ where } r \text{ and } \theta \text{ are the polar co-ordinates.}$$

This integral is obviously better than Mr. Edser's, since it gives the proper positive or negative value of V, whereas his gives a positive value in every case.

It should now be clear that there is not the slightest reason for introducing what Mr. Hughes calls "the most general case of a rectangular hyperbola of which the abscissa is the axis." On this point it appears that I am in agreement with the University of London. Their lecturers, to whom I have been referring, begin the discussion of the matter in the same way as I do; but they go on to make the serious mistake of supposing that the V is the length of the arc in the hyperbola as well as in the circle. What is even more serious, however, is the University's refusal to acknowledge that this is a mistake, after I have drawn their attention to the facts of the case.

Yours respectfully,
W. F. Dunton.

165, Tamworth-road, Newcastle-on-Tyne,
September 22, 1919.

APPOINTMENTS OPEN.

To the Editor of Engineering.

Sir,—I feel sure in writing this letter I quote the feelings of many, like myself, who have experience and are desirous of obtaining employment, but are disheartened on reading such advertisements as sometimes appear in your columns of "Appointments Open."

For example, we find for instance, a firm advertising for an assistant engineer with first-class experience in oil engines. Aged about 25, single, &c., &c. It appears to me very little or no credit is given for active service, and in the above case a demobilised officer, N.C.O. or man, has no chance, as it is impossible for the applicant to have completed his apprenticeship and also served his country.

The war has taken up five years, possibly the best five years of a man's life, and firms should take this into credit. Had we all remained in our pre-war jobs things would have been very different to-day, and in all probability these firms would not be in the position to offer employment. Therefore, it seems only fair that preference should be given to demobilised men of His Majesty's Forces. This being the case the prospective employer should raise his age limit at least five years and also take into consideration the fact that the applicant may be slightly out of date to the extent of five years, unless he has served in a unit where his engineering experience has been utilised.

I am sure very few want jobs given to them out of charity, what they do want is the chance to make good again. The majority of men looking for employment are those who joined up in the early stages of the war and, having been so long out of the engineering world, are forgotten.

There is still another point which needs adjusting, if firms want men they are, of course, prepared to pay for their services, therefore, why not state, salary about ——*l.* per annum, instead of salary required. This would give the applicant something to work on, otherwise he does not know whether the post is worth 100*l.* or 1,000*l.* per annum.

Respectfully yours,
"Experienced."

September 6, 1919.

The Junior Institution of Engineers.—The report of the Council of this Institution for the thirty-eighth session since its foundation in 1884, shows that it is growing apace, the year just ended being a record one in respect of the number of members added to the roll. The outstanding feature of the report is the long list of technical papers read and discussions held at its various meetings throughout the country. The subjects dealt with embrace almost all branches of engineering science, three whole pages of the report being occupied in recording the variety of its "transactions"—from planimeters to earthquake recorders; from aeroplanes to submarines; from shipping law to engineers' catalogues; from mechanical handling of goods to extraction of oil from seeds. Of similar importance and wide scope is the list of visits to works of engineering interest, paid by parties of members in London, Birmingham, Manchester, Sheffield, and Newcastle. In the establishment of the first Colonial local section at Melbourne, the Institution is shown to be taking a still more comprehensive step; there are signs of similar developments elsewhere overseas.

Accommodation in Continental Ports.—It is stated in *The Board of Trade Journal* that negotiations have been taking place for some time between German and American shipping companies, and that the latter, as well as European companies, such as the Danish East Asiatic Steamship Company, are making every endeavour to secure accommodation in Continental ports. The general situation, it seems, is that the powerful German shipping system has broken down, and that there is no chance of its recovering for some considerable time. There will probably be great traffic to and from Central Europe, and the newly-created States in Eastern Europe, and as these States have no merchant shipping of their own, and Germany cannot supply them with any, this valuable carrying trade is open to the first comer. America is, of course, making a strong bid for it, and Germany is inclined to assist her, while the Dutch and Scandinavians oppose her. It might be disadvantageous for Germany if America or the former neutral countries obtained the entire control of Central European shipping, while it would benefit her in the end if the British were to secure this traffic, on the assumption that England would let Germany have a fair share of this trade. The assertion is made that the chief of the Hamburg Emigration Board is anxious that the German emigration traffic should be carried on by British lines. At the same time, it is stated in one of the Hamburg papers that a New York shipping concern, called the Kerr Line, has arranged regular sailings between Hamburg and the North American ports. The announcement is made by the Hamburg-American Line, and it is said that the Kerr Line has been established by people who are closely connected with the Hamburg-American Line.

THE THREE-ELECTRODE THERMIONIC VALVE AS ALTERNATING CURRENT GENERATOR.*

By Professor C. L. FORTESCUE.

1. *Introductory.*—This paper deals mainly with work done during the war in the Wireless Telegraphy Department of His Majesty's Signal School, at Portsmouth; which constitutes the instructional and experimental centre for all matters pertaining to naval wireless telegraphy. The paper has been prepared in collaboration with the Superintendent of Signal Schools and his staff, has been submitted to the Admiralty and is now published with the Board's approval.

Thermionic valves were used in the Naval Service for the generation of high-frequency currents of small amplitude for reception by the "heterodyne" or beat method in 1914. De Forest's "Audion" valves were used, and the circuits were made up from existing Naval Service apparatus. Later sets used for the same purpose were made by the Marconi Company, the valves employed being those designed by Captain H. J. Round. In both cases the maximum high-frequency current was in the neighbourhood of 50 milliamperes.

During the spring of 1915 experiments were carried out with a transmitting valve of Captain Round's design, This valve was of the same general construction as those used with the small heterodyne sets. The filament consisted of a fine platinum wire coated with lime; the grid was made of nickel wire gauze; and a nickel positive electrode was supported by its natural springyness against the glass walls of the tube. The vacuum was not high, and no appreciable bombardment of the electrodes was carried out during the exhausting process; this being impossible owing to the large positive electrode being in contact with the glass walls of the tube. With this tube a high-frequency power of from 40 watts to 50 watts could be obtained. Experiments under actual signalling conditions were carried out, and some surprisingly long ranges were obtained. On one occasion one of His Majesty's Destroyers received comfortably readable signals when off the coast of Northumberland and when the high-frequency current in the aerial in H.M.S. Vernon at Portsmouth was only 0.6 amperes.

Considerable difficulties were, however, experienced on account of the lack of proper heat treatment of the valve in the course of the exhaustion, and the valves were not regarded as being sufficiently reliable to enable them to be used in ship installations.

At about this time the French too were experimenting with valve transmission, with a view to the development of wireless telephony.

Towards the end of 1915 some transmitting valves of the "oseillion" type were obtained from America by the Admiralty. These valves were exhausted to a higher degree than the Marconi valves and gave correspondingly better results. But the uncertainty of the supply and the still far from perfect results obtained made it evident that the requirements of a naval wireless telegraphy set using transmitting valves could not yet be met.

In the spring of 1916 a "Pliotron" valve made by the American General Electric Company was purchased by the Admiralty for experimental work. This valve, which was similar in construction to those described in the *General Electric Review* of May, 1915, and September, 1916, had been very thoroughly exhausted. It was normally worked with the tungsten positive electrode at a bright red or even yellow heat, and but for one small defect was probably the equal of any valve made up to the end of 1918. High-frequency currents of from 8 amperes to 10 amperes were obtained in an aerial of about 5 ohms resistence, and with only about 2,000 volts available for the supply to the positive electrode. Had a higher voltage supply been available there is little doubt but that the high-frequency power generated could have been doubled. On the only trial carried out for maximum range under signalling conditions, communication was established between H.M.S. Vernon at Portsmouth and His Majesty's Wireless Telegraph Station at Gibralta. This was in June, 1916, and at the time was second in range obtained with an oscillating valve only to the famous wireless telephone trial between Arlington, United States of America, and the Eiffel Tower.

It was recognised that although the Pliotron valves as then developed could not be manufactured on a scale sufficiently large to meet naval requirements, the elements of successful development were present, and exhaustive trials and experiments were continued by the Experimental Wireless Telegraph Staff on H.M.S. Vernon. The results of these experiments together with the information already published in the technical and scientific journals (principally American) enabled a fairly complete theory of the action of both the circuit and the transmitting valves to be worked out. This theory has formed the basis of all the subsequent designs.

Early in 1917 the first attempts were made to manufacture transmitting valves in this country to meet naval requirements. This attempt was undertaken by the General Electric Company at their lamp works at Hammersmith, in collaboration with the Naval Experimental Wireless Telegraph Staff.

Previous to this, although the advantages of valve transmission were fully realised, there had been no demand for additional lines of communication, the requirements of which could not be met by the existing arc or spark installations, nor was there any demand for the replacement of the latter by valve transmitters. Consequently, although the necessary conditions were investigated as fully as possible, no earlier steps were taken to start British firms on the manufacture of the larger valves, their staffs being already fully engaged on war work.

By a fortunate coincidence, however, the construction of these valves just preceded an urgent demand from the Grand Fleet for a valve transmitting set. The designs were worked out and eight sets were put in hand in the wireless telegraph workshops in H.M.S. Vernon. The first two of the sets were despatched to the Grand Fleet on the night of Good Friday, 1917, within six weeks of the demand for the sets arising. Some two months elapsed during which lengthy trials were carried out. On the strength of these trials it was decided to fit similar sets in a considerable number of ships. Contracts were placed with various instrument making firms, and within one month the first of these sets was on its way north, not complete in every detail certainly, but sufficiently complete for satisfactory service.

Meanwhile numerous experiments were conducted by the Wireless Telegraph Staff of the Admiral Commanding Reserves with Marconi valves installed in wireless telegraph stations located round the coast of the British Isles. These experiments gave useful information and showed that results could be obtained even with valves that were only partially exhausted. In particular they demonstrated the advantage of working with high voltages for the supply to the positive electrode.

The success of the first valve transmitting sets in the Grand Fleet led quickly to a demand for other sets of greater power. In the autumn of 1917 a larger set was designed to work from the power supply of existing spark apparatus. The trials of this set were carried out during the winter of 1917–18, the details of the design being finished early in 1918. The apparatus was being fitted in ships as it became available throughout the whole of the summer of last year. To a great measure the success of this set was due to the type of aerial tuning inductance employed. This coil was designed by the Wireless Telegraph Staff at Portsmouth, primarily for use with Poulsen arc sets. The work previously carried out by this staff in connection with the design of inductances may be said, in fact, to have contributed more to the success of the valve sets than any other single item except perhaps the design of the valves themselves.

Whilst the parts of this more powerful set were being manufactured, yet higher power sets were being experimented with for use on board ship and in the Admiralty shore stations. Outputs and ranges almost equal to those of the smaller Poulsen arcs were obtained, and the many advantages of the valve transmitter pointed to the certainty of it replacing the arc in the near future for all purposes except in the very highest powered land stations.

Valve transmitting sets also had their application in the other services—the Army and the Air Force. The direction and the nature of these applications have already been described by Lt.-Colonel Cusins, R.E., and by Major Erskine-Murray before the Wireless Section of the Institution of Electrical Engineers.

A similar development was, of course, also taking place in France and in America. Valves of very considerable power were being experimented with in France in 1917 under the direction of General Ferrié. In America the development was more in the direction of quantity production of relatively small power tubes for short range telegraphy and telephony work.

Wireless telegraphy and telephony do not constitute the only spheres of utility of the three-electrode valve as an alternating current generator. For laboratory and testing purposes it is rapidly taking the place of all other sources of alternating current where frequencies above about 200 cycles per second are required.

The successful application of the valve transmitters to naval wireless was largely due to the valuable assistance of the following permanent and temporary members of the Naval Experimental Wireless Telegraph Staff, viz.:—Messrs. W. A. Appleton, B. S. Gossling, H. A. Madge, H. Morris-Airey, and C. M. Sleeman; of Captain J. A. Slee, C.B.E., R.N., formerly on the staff of the Admiral Commanding Coastguard and Reserves; of Captain H. J. Round, M.C., formerly attached to Army Signals, and of Dr. G. B. Bryan, Assistant Professor of Physics, Royal Naval College, Greenwich.

2. *The Action of the Three-Electrode Valve as an Alternating Current Generator.*—The conditions necessary for a three-electrode valve to act as a generator of alternating currents have been investigated by others besides the workers at His Majesty's Signal School, Portsmouth. Notably, Haseltine* in the Proc. Inst. Radio Engineers, has given a very complete investigation on the requirements. Vallauri† has also worked out the critical condition for a few particular cases. Recently Eccles has shown, before the Physical Society of London, a method of investigating the problem by a graphical method.

In the great majority of cases the valve is used in conjunction with an inductance and a capacity. In an electrical system, inductance plays the same part as inertia in a mechanical system. Capacity on the other hand is the analogue of the springyness or elasticity of a spiral spring or similar structure. A heavy weight suspended from a spring has properties closely analogous to a combination of an inductance and a condenser in an electrical circuit. A still closer analogy is that shown in Fig. 1.

The figure represents a spring controlled piston capable of moving in a cylinder. The two sides of the cylinder are connected together by a considerable length of large diameter piping, and the whole system is full of water. Normally the two springs S S maintain the piston in a central position. But as shown in the figure the piston is displaced from its normal position and is held there by means of the catch Z. If now Z is withdrawn the springs will tend to return the piston to the mid position. The piston will not take up this position instantaneously, however, because it has weight and therefore inertia. But more important at the moment, the piston cannot reach the normal position except by moving a considerable quantity of water round through the piping from one side of the cylinder to the other. This water also has inertia. The actual result is that on the withdrawal of the catch Z, the piston starts moving towards the mid position under the force exerted by the springs. The rate of movement of the piston and the water will gradually increase (so long as the pipes are of large diameter and give rise to relatively little friction) and when at last the piston does reach its normal mid-position it and all the water in the pipes may have attained to quite a high speed. As a result of this velocity the inertia comes into play again and both water and piston overshoot the mid-position, coming to rest at a point considerably to the left of the centre in Fig. 1. The process is then reversed. The piston and the water with it move back to the right, over-run the mid-position, and finally come to rest again somewhere near the position from which they were originally released by the withdrawal of the catch Z.

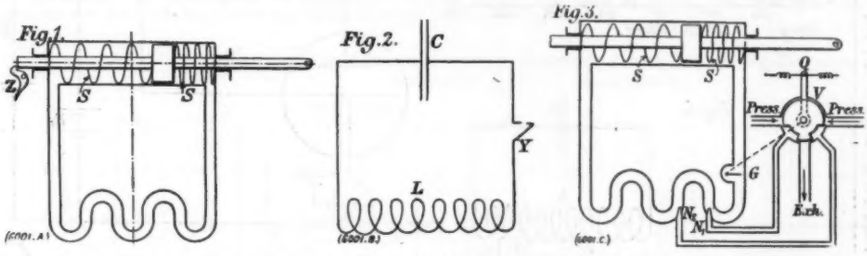
This process of oscillating to and fro may go on several times before the piston and the water ultimately come to rest. Each successive excursion to the left or right will be less than the preceding one owing to the friction of the piston in the cylinder and of the water in the pipes.

The time required for the piston to make one excursion out to the left and to return again to rest on the right will depend upon two things, viz.:—

(*a*) The quantity of water which has to be transferred from one side of the piston to the other for a given restoring force from the springs.

(*b*) The inertia of the water in the pipe, which depends upon the length of the pipe and the velocity of the water in the pipe relative to the velocity of the piston.

An increase of either of these two factors will delay



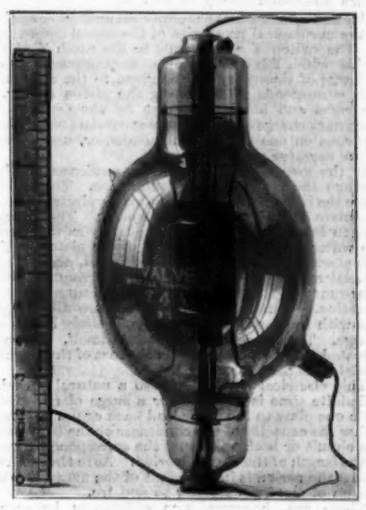


FIG. 4.

* Paper read before Section G of the British Association at Bournemouth, September, 1919.

* Proc. Inst. Radio Engrs., April, 1918.
† L'electrotecnica, January 25, 1917.

the movement of the piston. The time required for the piston to move from a position of rest on the right, out to the left and back again to the right is, however, independent of the distance moved to the right and left. With the greater amplitudes the springs are more compressed and so exert correspondingly greater forces. These forces give correspondingly greater accelerations to the water with the result that the time required for one cycle is the same for the large amplitude as for the small one. This interval of time is known as the natural period of the system. The period will differ with different systems, being greater with large diameter pistons and weak springs, and with long connecting pipes.

Hydraulic engineers will realise that it would be difficult to construct a piece of apparatus of this kind in such a way that it would make more than a very few oscillations. This fact, however, is not relevant to the use of the model as an illustration of the action of the inductance-capacity electrical circuit.

An electrical condenser consists of a number of flat conductive plates separated from one another by thin layers of non-conducting material. Some condensers are "fixed," i.e., are arranged so that the number of plates and the thickness of the insulating medium between them is always the same. These condensers have a constant capacity for storing up electrical charge. Other condensers, again, are constructed so that the number of plates in use, or their distance apart, or both, can be varied. Such condensers have variable capacity for storing up electric charge. The conducting plates are usually of copper or zinc, or alloys of these metals. The thin layer of insulating material may consist of glass or ebonite or mica or air.

An inductance consists of a conducting wire wound up into a spiral of a large number of turns, along which a current of electricity can be passed.

An inductance L connected up to a condenser C is shown diagrammatically in Fig. 2.

Such an arrangement has electrical properties analogous to the mechanical properties of the model shown in Fig. 1. The switch Y corresponds to the catch Z of Fig 1. If this switch Y is open, there are various means by which a charge of electricity can be given to the condenser C. This corresponds to displacing the piston of Fig. 1 to the right and holding it there by the catch Z. The stationary charge in the condenser consists of an excess of electrons on one plate of the condenser, usually known as the negative plate.

If the switch Y is closed the condenser discharges through the circuit of the inductance. This discharge takes the form of a stream of the excess electrons from the one plate of the condenser to the other. The inductance acts to this stream of electrons exactly as the inertia of the water affects the movement of the piston in Fig. 1. The starting up of the stream is delayed, and then when neutral conditions are realised the stream of electrons over-runs and the condenser is charged up in the reverse direction. Ultimately the electrons are all brought to rest with the condenser charged oppositely to the initial charge. The process then reverses itself, and may be repeated many times, just as in the case of the mechanical model of Fig. 1.

This electrical circuit has also a natural period, i.e., a definite time is required for a surge of the electrons from one plate to the other, and back again. Increasing either the capacity of the condenser or the inductance of the circuit or both will cause the corresponding increase in the length of the natural period. As in the mechanical model the period is independent of the magnitude of the stream of electrons surging to and fro.

There are, however, two differences between the mechanical and electrical cases, more of a numerical nature than of principles involved.

In the first place there is no difficulty whatever in constructing capacities and condensers so that as many as 20 or more complete oscillations are gone through before the amplitude falls to say one-tenth of the original value. Then, secondly, the whole scale of time is different for the two cases. The electrons are so small and nimble as compared to the ponderous molecules of water that their rates of movement are very much greater. Where with the mechanical model it would be expected that the piston would move to and fro at the rate of one complete oscillation in something of the order of a few seconds, the oscillations in the electrical case may take place in a similar number of millionths of a second. It is in fact inconvenient with the electrical arrangement to provide for oscillations at a rate of less than 100 a second.

The movements to and fro of the piston of Fig. 1 do not constitute an analogy to an alternating current. They only go on for a few oscillations and then the piston comes to rest for good. These movements are analogous to what is known as a "damped oscillation" in the electrical circuit.

To represent an alternating current something must be done to the model to keep the piston oscillating at the rate at which it naturally tends to move when left alone. One conceivable method of doing this is shown in Fig. 3. A vane G is introduced, which operates a double-ported valve V. Normally the vane is maintained in a central position by the light springs attached to the arm Q. But the stream of water past the vane will deflect it upwards and downwards and in so doing will open and close the valve. When the vane is deflected upwards the nozzle N_2 is connected to a high-pressure supply so that a jet of water enters the system so giving an impetus to the upward stream of water. When the water is flowing downwards the vane will be deflected downwards and a jet of high-pressure water enters through the nozzle N_1; again tending to maintain the stream. In order to prevent an accumulation of water in the system the nozzles must be alternately connected to the exhaust as indicated in the figure.

With such a piece of apparatus it is quite conceivable that the nozzles and the ports of the valve could be so arranged that the oscillating to and fro of the piston was just maintained by the impulses of the water from the high-pressure system.

This method of converting the mechanical damped oscillations of the piston into continuously maintained oscillations is very closely analogous to the action of the three-electrode valve in the electrical case. It acts as a combination of the vane and the water valve, and its function is to allow suitably-timed impulses of current from a high-pressure battery to pass through a part of the inductance and so convert the damped electrical oscillations into the continuously maintained oscillation known as an alternating current.

The principles of the action of the three-electrode valve have already been described on many occasions. For the purpose of generating alternating currents a highly exhausted valve is generally used. Fig. 4 shows the construction of such a valve. In the centre is a tungsten filament similar to the filament of an ordinary incandescent lamp. This filament is raised to a temperature generally somewhat higher than that used in the incandescent lamp, and under those conditions there is emitted from its surface a copious supply of free electrons.

Surrounding the filament is a cylindrical electrode, which is maintained strongly positive to the filament by some external battery, dynamo or other source. The electrons from the filament are attracted by this positive electrode, fly across to it from the filament, and so constitute a current of electricity across the vacuous space inside the tube.

The third electrode of the valve consists of a more or less open screen placed between the filament and the positive electrode, in such a position that the stream of electrons from one to the other has to pass between the openings in the screen. This third electrode is usually known as the "Grid," and its function is to control the stream of electrons from the filament to the positive electrode. If the grid is connected up to a battery so that it is negative to the filament, it repels the electrons into the filament, and it is only when the positive electrode is very strongly positive indeed that any electrons are attracted through the openings of the grid screen. On the other hand, if the grid is maintained slightly positive with respect to the filament, it assists in attracting the electrons away, and a large stream from filament to positive electrode will be maintained. If the grid is made very strongly positive to the filament it acts itself as the positive electrode and attracts a large proportion of the electrons, with the result that the stream across to the positive electrode proper is reduced.

Characteristic curves showing the control exercised by the grid electrode are shown in Fig. 5. In this figure the voltage of the grid with respect to the filament is plotted horizontally, and the current at the positive electrode is plotted vertically for three different values of the steady positive voltage applied to that electrode.

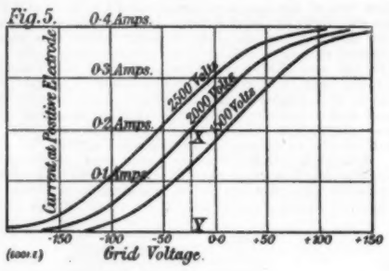
From these curves it is observed that with the grid negative to the filament it is only with high voltage on the positive electrode that the current at this electrode is appreciable. As the grid becomes in turn less negative and then moderately positive, the current at the positive electrode gradually increases to a more or less clearly defined maximum value. This maximum value corresponds to the total rate at which the free electrons are emitted from the filament, and the hotter the filament is the greater will be this rate of emission, and the greater will be the maximum value of the current. After this maximum has been reached any further increase of the positive voltage of the grid will lead to a decrease of the current at the positive electrode because of the diversion of an appreciable proportion of the electron stream to the grid itself.

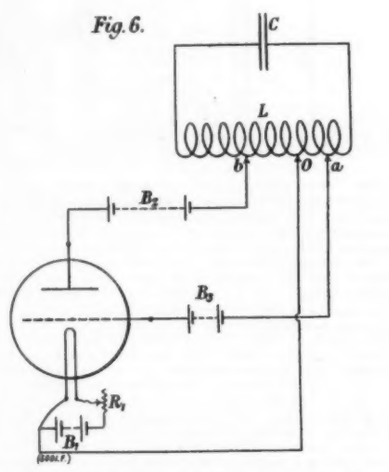
The voltage of the grid thus controls the electron stream somewhat in the same way that the opening and closing of a stopcock controls the stream of water in a water main. The analogy is not quite exact, but is sufficiently good for the purposes of illustration.

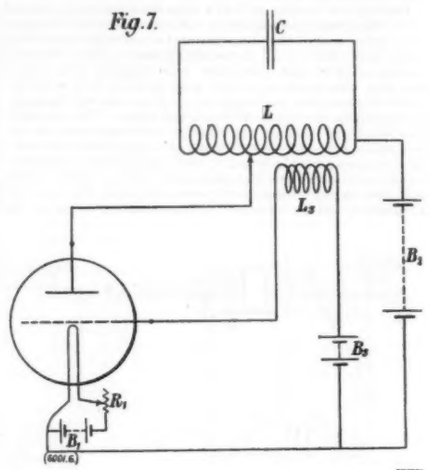
There are many ways of connecting up a three-electrode valve of this kind to an inductance-capacity circuit so as to maintain the oscillations. One of the simplest is that shown in Fig. 6. Here C is the condenser and L is the inductance. The filament of the valve is heated by a battery B_1, the heating current being controlled by the resistance R_1. The filament is directly connected to a point O on the inductance. The positive electrode is connected to a point *b* on the inductance through a battery or other source B_2. The grid is connected to a point *a* on the inductance, on the opposite side of the point O to that of the point *b*, with a battery B_3 in series.

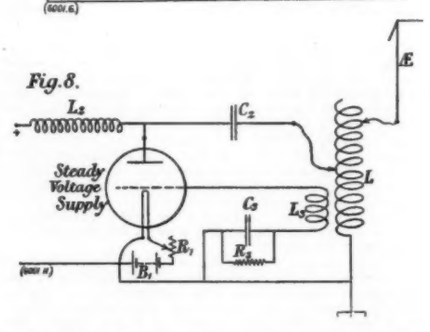
The filament current and the voltages of the batteries B_2 and B_3 are adjusted so that the steady conditions correspond to a point X on the curves of Fig. 5. A steady current of value X Y will then be flowing through the part O *b* of the inductance. If now the inductance-capacity circuit be caused to oscillate by any means, the induced E.M.F. in the part O *a* of the inductance will act upon the grid and will cause a rise and fall of the voltage with respect to the filament. This rise and fall is accompanied by a rise and fall of the electron stream reaching the positive electrode, and so by a rise and fall of the current through the part O *b* of the inductance L. This rise and fall of the current through O *b* acts upon the electrical circuit just as the alternating rush of high-pressure water from the nozzles of Fig. 3. If the points *a* and *b* on the inductance are suitably chosen any small oscillation in the circuit L C will be assisted and built up into an oscillation of magnitude depending upon the power output of the valve and the energy loss in the circuits.

Assuming that there is no time lag in the adjustment of the electron stream to the changes of grid voltage—as should be the case theoretically for all frequencies up to 10,000,000 or more per second—then this arrangement of a valve with a capacity-inductance circuit becomes an alternator of frequency depending upon the natural frequency with which the current in the circuit will oscillate. By adjusting the capacity and the inductance to suitable values, this frequency can have any desired value from at least 10,000,000 cycles per second, downwards to frequencies of 250 cycles per second or even less if somewhat bulky apparatus is









not objected to. If either the inductance or the condenser or both are made quickly variable by turning a handle, the adjustment of the frequency to any required value within the range of the particular set of instruments in use can be carried out with a minimum of trouble. This property is invaluable for wave changing in wireless telegraphy or where the generator is used for laboratory testing purposes.

The circuit arrangement of Fig. 6 is but one of many possible ones. For instance, Fig. 7 shows a very commonly used circuit. Here the grid is influenced by the induced E.M.F. in the coil L_3 instead of by the induced E.M.F. in a part of the main coil L, as in Fig. 6. Fig. 8 shows a very convenient circuit arrangement for a valve transmitter for wireless telegraphy. This arrangement is in principle the same as Fig. 7. The addition of the condensers C_2 and C_3 and of the inductance L_2 are for reasons of practical convenience rather than difference of principle. For example, the aerial system is insulated from the high-voltage source by the condenser C_2. This condenser allows the high-frequency currents necessary for the maintenance of the aerial current to pass through it freely, but does not allow any steady current to pass. Thus a failure of the insulation of the aerial does not lead to a short circuit of the high-voltage supply. And, again, if the parts of the aerial circuit are inadvertently touched by anyone standing near, no serious harm is done, whereas a shock from the high-voltage supply would almost certainly be fatal.

(To be continued.)

THE SCIENTIFIC PROGRESS OF AVIATION DURING THE WAR.*

By MR. L. BAIRSTOW, F.R.S., C.B.E.

IN a recent lecture to the memory of Wilbur Wright attention was drawn to certain generalisations reached in estimating the performance of aeroplanes. No attempt was then made to go below the surface of things owing to restrictions of time, and to-day it is proposed to devote the available time to more fundamental problems.

No single case of fluid motion round objects used in aviation has as yet been deduced from a solution of the equations of motion, and the process followed has been frankly empirical. One of the more important early problems was the finding of that shape of aeroplane which gives minimum resistance for a given lift due to motion. Within somewhat narrow limits this problem has been solved, and for some time it has been possible to say that an aeroplane of good design will fly at a speed known from its weight and horsepower. Similar standard results apply to the rate of climb of an aeroplane and the height to which it can climb. Two extremes of size are SE5a with a total weight of 2,000 lb., and the Handley Page V-type with a gross load of nearly 30,000 lb. The spans of the machines are 25 ft. and 130 ft., the powers 210 and 1,500, and the maximum speeds 130 m.p.h. and 95 m.p.h. respectively. The differences of performance are not due to size but to the change from a power of 105 for each 1,000 lb. of gross weight for the SE5a to a power of 50 for the Handley Page.

Both are biplanes with the wing resistance much greater than that of the rest of the aeroplane at economical speed, and in general, aeroplanes have always more than half the resistance accounted for by the wings. Owing to the importance thus indicated wings have been studied in great detail on models, and the general aerodynamic agreement of modern aeroplanes is to a large extent due to the fact that makers have chosen the wings from the most efficient forms so determined. A sacrifice of nearly 20 per cent. in power is admitted for constructional reasons, a loss of that magnitude being the result of placing two wings as near together as they are in the average biplane.

Model to full scale.—Fortunately for aeronautics, a statement of the law of variation with scale was given by Lord Rayleigh in the first volume of the reports of the Advisory Committee for Aeronautics. The theorem given below has kept experimental work on sound lines, and has now extensive experimental support. The theorem is

$$R = \rho v^2 l^2 f\left(\frac{v\,l}{\nu}\right) \quad . \quad . \quad . \quad (1)$$

where R is the resistance to motion of a body of typical dimension l moving at a velocity v through a fluid of density ρ and viscosity ν.

The equation is derived from the theory of equality of dimensions and is the most general form consistent with the assumptions made as to the quantities on which resistance depends.

The full meaning of the theorem is only appreciated after long contact with applications. It is at first sight strange that a law for similarity of motions can be deduced when neither motion is calculable. This failure to calculate is shown in (1) by the fact that f is an undefined function. If we try to apply the theorem directly to the relation between models and aircraft, the choice is limited to making $\frac{v\,l}{\nu}$ the same for both since this is the only condition which does not involve a knowledge of f. With a model in air the equation shows that the force on the model aeroplane must equal that on the aircraft and as a consequence the smaller the model and the higher the speed of test should be. On the other hand, the speed must not be a large fraction of the velocity of sound or air cannot be considered as incompressible. Lord Rayleigh showed by calculating the adiabatic flow of a frictionless gas that a reasonable limit of speed would be 500 f.s. The law of corresponding speeds indicated by equation (1) is then often impracticable.

If closer examination be made, a more hopeful view is possible. The resistance of bodies at aeroplane speeds is found experimentally to vary roughly as the square of the speed and some considerable refinement of method will be required to show departures from this law. If the v^2 law were strictly true then $f\left(\frac{v\,l}{\nu}\right)$ would be a constant and an experiment at any speed, and on any size of model would gives its value. If further accuracy is desired, it must at present be sought by a determination of f in a few typical cases, and this leads to the idea of nearly similar motions. Changes in f are known to us which would not be covered by the expression "nearly similar" and are usually associated with critical velocities. The early part of the curve of resistance to motion in pipes as dependent on $\frac{v\,l}{\nu}$ represents a calculable motion, and the details of the flow are therefore known. When $f = 0{\cdot}004$ its value begins to change rapidly, and Osborne Reynolds showed that this change coincided with the commencement of eddying motion. For large values of $\frac{v\,l}{\nu}$ the flow is incalculable, but becomes regular in the sense that the type of flow changes gradually and not abruptly over a very large range of the variable $\frac{v\,l}{\nu}$. For short parts of this range the motions might be regarded as nearly similar.

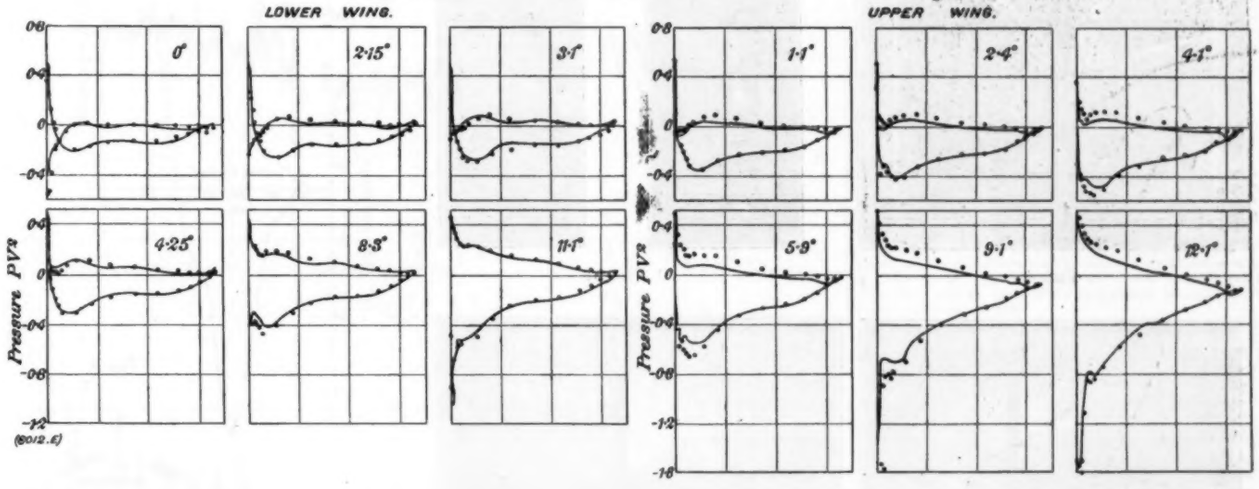
The experimental evidence in this instance covers large changes of v and l, and has an important theoretical value. Knowledge of the coefficient of viscosity was originally based on the laminar flow of fluids, and its extension to unsteady flow was not fully established prior to such experiments. It is now shown, however, that ν is applicable to all states of motion, and turbulent motion could be made the basis of a determination of relative values in two fluids. The accuracy obtainable would usually be small because of the relatively slow change of $f\left(\frac{v\,l}{\nu}\right)$ with $\frac{v\,l}{\nu}$ when the motion is eddying.

Smooth wires.—As a further example of the application of equation (1) may be given the case of smooth wires. In the range investigated there is no critical change of the kind found for smooth pipes and except for small wires at low speeds the coefficient of resistance $f\left(\frac{v\,l}{\nu}\right)$ does not vary greatly. This is one of the instances covered by the law of corresponding speeds, for there is no difficulty in doubling or trebling the size of wire and testing at a suitable speed. The curve of resistance coefficient as a function of $\frac{v\,l}{\nu}$ indicates that it is desirable to eliminate wires from a complete model aeroplane if the conditions of test bring vl to a value at which the resistance coefficient is much different from that on the full scale.

The difficulty of determining f experimentally on the full scale will be appreciated when it is realised that an aeroplane must be complete and in flying order. It is possible to measure local effects by the determination of the pressure at a point, and for wings this method has been tried with the results shown in Fig. 1. The model was to one-tenth scale, and the agreement with the two sets of tests is satisfactory. Small residual errors are not improbably experimental.

Fluid motions.—The experimental difficulties are sufficiently serious to reopen the enquiry as to the

Fig. 1. COMPARISON OF PRESSURE PLOTTING ON MODEL & FULL SCALE BIPLANE WITH R.A.F. 14 WINGS.
Full Scale —— *Model Points* ·····



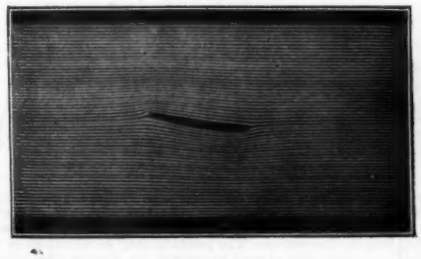


FIG. 2.

FIG. 3.

* Paper read before the British Association, G Section, September, 1919.

possibilities of mathematical solution. The latter method would not only show the existence of critical changes and departures from similarity but would show why they occur, and therefore make a safer base on which to generalise. The known mathematical solutions in a free viscous fluid relate to slow motions, such as that of small spheres and flow through capillary tubes. The largest class of calculable motions is illustrated by Professor Hele Shaw's experiments in which a viscous fluid is forced between parallel plates round obstacles of any shape. These motions are all calculable up to the first critical velocity. In the case of a wing this critical velocity depends greatly on the angle of incidence, and the records shown in Figs. 2, 3, 4 and 5 are of considerable interest in the present connection. The first photograph, Fig. 2, was taken by the author with apparatus kindly lent to him by Professor Hele-Shaw. The fluid was water, in a layer about 0·01 in. thick and the features to which attention is now called particularly, are the closing of the stream lines at the rear of the wing section and the upward direction of the streams there. At a short distance behind the obstruction the effect of it

Fig. 4

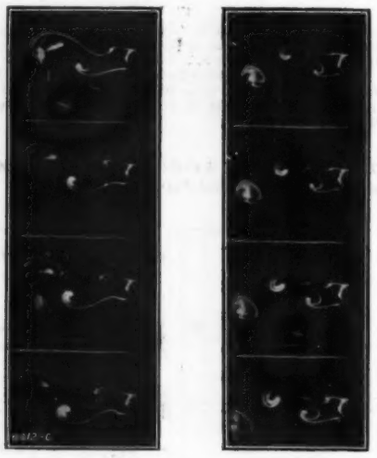


Fig. 5.

Fig. 6

Fig. 7

has practically been eliminated. Fig. 3 shows a corresponding photograph for water when the layer was several inches thick, and the constraint of the walls therefore small. The disturbance of the stream is obvious for some considerable distance to the rear as is also the downward tendency of the streamlines. The loss of velocity is also evident from the change in length of the dashes which represent movement in equal intervals of time (roughly ¼ sec.). The motion is no longer calculable but is still steady and free from eddies.

At a larger angle of incidence the velocity of the fluid in the rear of the wing becomes very small, and at a still larger angle eddying becomes pronounced Fig. 4. How do these observations compare with those on the full scale:—Comparison is indirect but both on models in wind channels and on wings in flight there is a stage during which lifting force is obtained with small resistance, followed by a well known change at 15 deg. to 20 deg. such as might be expected to result from the production of eddies. The free water experiment, therefore, appears to contain the essential features of the motion round aeroplane wings and a mathematical solution of the steady flow and a search for the criterion of breakdown promises results of great value in the event of success. An investigation on the lines indicated has been interrupted by the war, but has recently been recommenced with the aid of a grant from the D.I.R. This has made it possible to enlist the whole time assistance of Miss Cave, and considerable progress has been made. The labour of the processes is formidable, although they are being improved continuously.

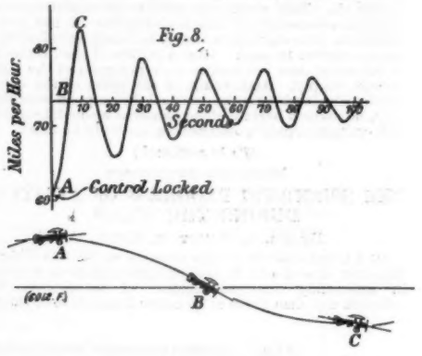
Cylinders and flat plates normal to the wind are usually associated with the production of eddies, but a little consideration shows the probability of an intermediate stage of steady flow. Fig. 5 shows a number of cinema photographs of the eddies behind a cylinder, the white lines being produced by the emission of milk through holes in the side of the cylinder. The growth of the eddies is shown very prettily, but the impression given is different to that obtained from the inclined wing (see Fig. 4). The difference is, however, only apparent as was seen when the two methods of indicating motion were used simultaneously to indicate the flow behind a cylinder. The milky patches have the form shown for the cylinder in Fig. 5, whilst the streaks have the form indicated for the wing at a large angle of incidence. The direction of flow may be normal to the direction of the milk streaks.

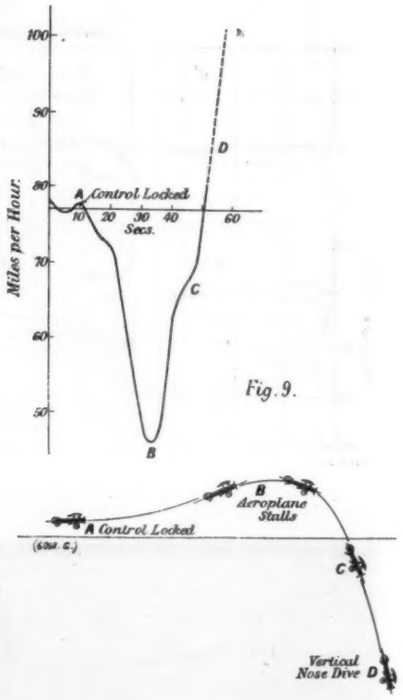
It is probable that eddies behind a plate have the same general character, and the next two slides show a change with $\frac{v\,l}{\nu}$ for a plate which is not eddying. The photographs (Figs. 6 and 7) were taken with Professor Hele-Shaw's apparatus, and in the first the speed was as low as possible in order to get a good picture, and the width between the plates as great as it was convenient to work with (about 0·02 in.). The first picture shows symmetry before and behind the plate, and belongs to the calculable series of motions. In the second experiment, Fig. 7, the speed was increased many times with a marked change of flow which is still steady. In the first experiment the forces on the fluid due to viscosity were very great compared with the changes due to inertia and the latter were negligible. In the second, the viscosity will be seen to have been insufficient to suppress the effects of inertia due to high velocity round the corner of the plate.

The experiments indicate a fundamental line of enquiry which is still in its infancy but which promises well.

Element theory.—In order to make existing experimental results go as far as possible in detailed design, a theory of elements has been developed which has been the basis of all airscrew calculations, and has latterly been extended to cover some of the complex motions of aeroplane such as spinning. In this manœuvre the pilot, flying horizontally, cuts off the engine, and as the speed falls, increases the angle of incidence of the wings until the angle exceeds 20 deg. The rudder is then put hard over and the aeroplane turns and puts its nose down. Shortly afterwards the body is nearly vertical, and the aeroplane is rotating about the vertical in a period of 2 or 3 sec. The phenomenon appeared to be closely connected with the breakdown of flow over the wing tip and the hypothesis was confirmed by test on a model. Supported on an axle along the wind the model was balanced and free to rotate. For an angle of incidence of 10 deg. the effect of the wind current was to produce an aimless wandering due to slight unsteadiness. At angles of 20 deg. to 30 deg. however, a steady spin was produced, the direction of which depended on the direction of the initial accidental disturbance. The condition of no rotation was found to be definitely unstable and an attempt was made to apply an element theory to the calculation of the rate of rotation. The success attained was very considerable, and is good support for an element theory. The fundamental hypothesis made is that the flow of air round a part of a body is not appreciably affected by changes in the shape of the neighbouring sections. The theorem must be applied with caution, and in the case of airscrews an extension has been introduced to allow for the effect of the previous passage of the blade element itself and of other blade elements through the region of air under consideration.

High speed airscrew.—A discussion of some importance has been raised by the conflicting requirements of airscrew designers and engine makers. It is apparent from the trend of engine design that crankshaft speeds of 2,500 r.p.m are contemplated in order to reduce weight per





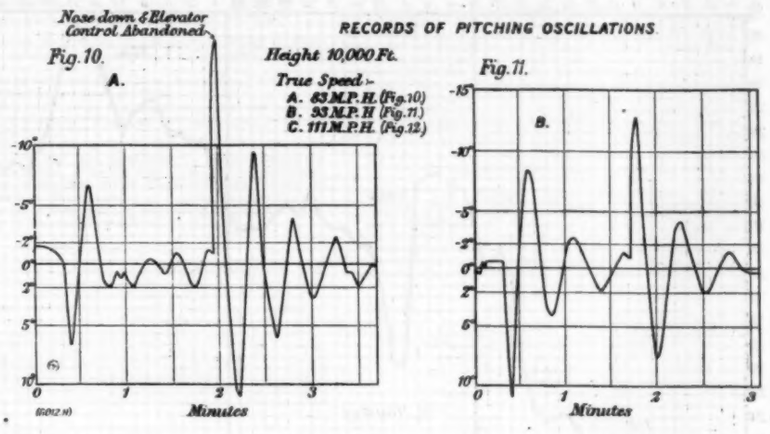
horse-power. On the other side, the airscrew designer finds a loss of efficiency of the airscrew which becomes serious at high speeds and much greater than any gearing loss in the engine. The position may be accepted as well grounded, and it was necessary to discuss the relative value of numbers as represented by the simplification of an ungeared engine and quality as represented by high performance. If, for civil flying, it may be anticipated that the engine unit will have a horse-power of about 400, the gearing for a "tramp" aeroplane should bring the airscrew revolutions down to 1,000 or 1,200 r.p.m. If necessary, four-bladed airscrews can now be used, and the slow rotation and large diameter will not only tend to high efficiency but probably also to quieter running.

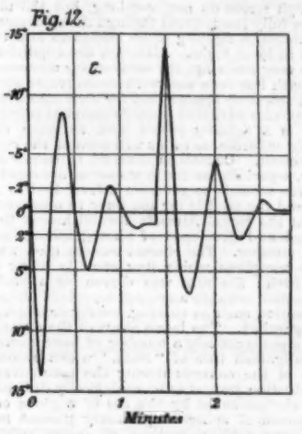
The use of ungeared engines and large powers was bringing a new feature into the theory of airscrew design. Tip speeds of 600 ft. per second are not uncommon even with gearing, and airscrews have been used with tip speeds in excess of 850 f.s. On theoretical grounds it was anticipated that changes in the type of air flow from an airscrew would begin to appear at about 500 f.s., or roughly half the velocity of sound in air. These changes were affecting design, and experience factors of increasing

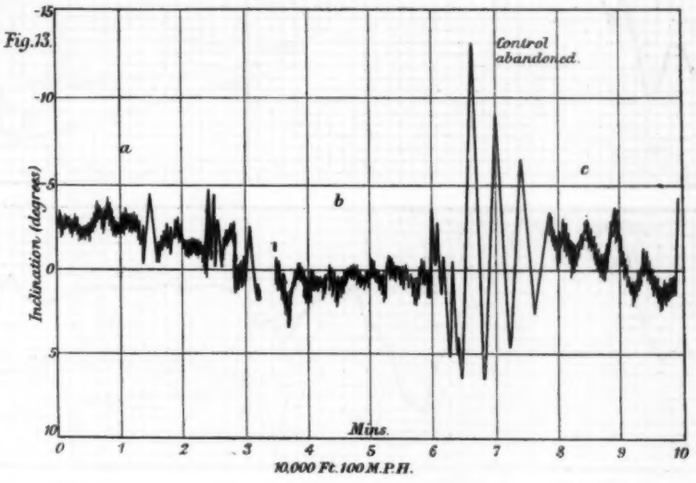
magnitude were being introduced to meet the new conditions of operation of airscrews.

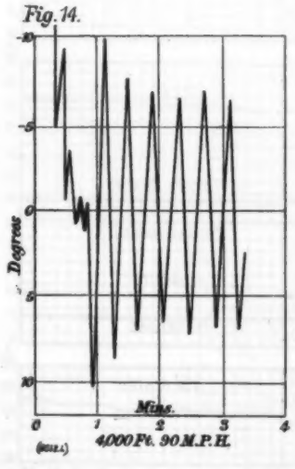
The importance of the subject was becoming very great in the closing period of the war and a special design was made at the Royal Aircraft Establishment which could be rotated on the spinning tower at speeds up to nearly 1,200 f.s. The results obtained were very striking, the simplest of observations sufficing to indicate a great departure from the type of flow on which normal airscrew design is based. Standing in the rear of the airscrew, the usual strong breeze was felt at speeds below 900 f.s., but disappeared before the top speed of 1,160 f.s. was reached, leaving a region of comparative calm. The change was noticed more readily on shutting down owing to the suddenness with which the slipstream made its re-appearance. The phenomenon was more closely investigated and it was found that the new type of flow was largely centrifugal, whereas the normal flow resembles that in a jet of rather less diameter than the airscrew. There was no sudden increase in the rate of variation of power with speed, but considerations of momentum suggest that almost the whole of the thrust had disappeared. As an organ of propulsion, the airscrew was probably very inefficient whilst the noise produced was a source of extreme discomfort.

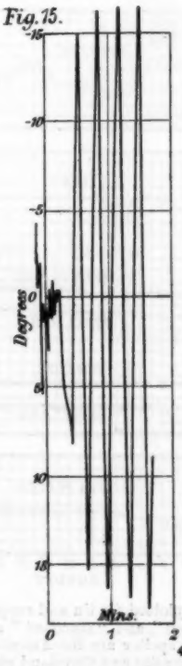
RECORDS OF PITCHING OSCILLATIONS.

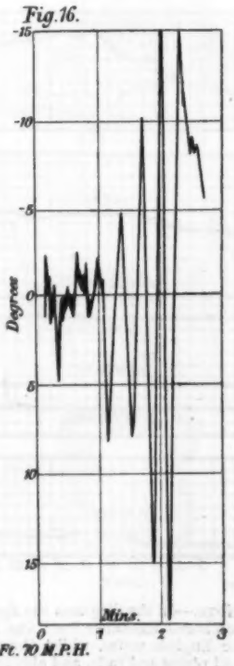












Factors of safety.—I am not going to deal with the calculations made when estimating the load which an aeroplane can safely bear, but to draw attention to the loads which may come on it due to its motion through the air. A difference between military and civil flying is shown in the process, and it will be seen that the fighting pilot carried out his work under exciting conditions during which his aeroplane was subject to severe strain, and in which his physical sensations must have added considerably to those due to the presence of an enemy. Needless to say the records shown were taken in a "mock fight," and require extension by the use of some little imagination before they are taken as representative of those in a "real fight."

The forces on an aeroplane can be measured by a delicate little instrument called an "accelerometer." Although it has a good scientific name it has also the merit of being a very prosaic instrument which measures the heaviness with which a pilot sits on his seat. Ducking the nose of the aeroplane tends to throw the aviator out, and at the moment at which he loses his seat the instrument reads zero. During a loop it may indicate that instead of a real weight of 10 stone, the pilot's apparent weight is 40 stone. His head is then very heavy on his shoulders, and on the one occasion on which I experienced the sensation my head was distinctly unstable, and an incautious movement brought it forward "out of control."

The first record occupied nearly half an hour in the taking, of which about 20 min. was in the air. The instrument, designed by Dr. Searle, F.R.S., of the R.A.E., was strapped to the knee of an observer, and at intervals the pilot interposed some of the trick evolutions of flying on the more normal course of the flight. The first clear deduction from the record is the uneventfulness of straight flying, especially at good heights. This is shown by the tendency of the record to keep about the value 1, so that the pilot and passenger have their usual weight. Flying low down it was noticed that the changes called "bumps" sometimes reduce a pilot's apparent weight to half its ordinary value, and at other times increase it to nearly one and a half times. The sensations are very like those experienced on a switch-back or mountain railway, and in a well-shielded cockpit this is the only noticeable effect of motion on the sense of feel. The earth, however, becomes far less impressive as the representative of solidity and has its attributes transferred to the aeroplane. So much is this the case that in a loop it is the earth which goes over your head whilst in a banked S turn the waves of a high sea are less wonderful than the swaying of the earth. These impressions are very real, and have a rational basis; we are so accustomed to living on the earth and to the use of such instruments as levels that it needs a definite effort to realise that on an aeroplane a level does not indicate the horizontal. On the contrary a level will consistently say horizontal when the aeroplane is banked to 45 deg. or more, and not only does the level say this, but the pilot's sensations of feel tell him he is sitting upright. In the absence of sideslipping the local level is given by the wings of an aeroplane. With an horizon visible a pilot can keep level relative to the earth by the use of his eyes, but this power is removed by immersion in a cloud. By the use of instruments of a not very intricate nature, straight flying can be conducted in a cloud, and fog is not by any means an insuperable bar to aerial navigation.

Leaving the record of ordinary flight and coming to the "stunts" it will be found that on two occasions the pilot was in danger of leaving his seat, and the importance of a belt will be appreciated. Looping and spinning produce heaviness on the whole, the extreme value being nearly three times the normal. A rapid turn almost always increases the apparent weight, and in a mock fight it is very noticeable that the greater number of manœuvres seat the pilot more solidly, and therefore

help in the accurate control of the aeroplane's motion. In a few instances and for a few seconds the apparent weight is zero, whilst the extreme in the other direction is as great as four times the normal.

Periods of high stress do not last long, but the air forces have been fully transmitted through the structure, which is then liable in fighting to be loaded to four or five times that in level flight. Although the condition of fighting are very exacting, the demand for adequate structural strength has been met with considerable success. It would therefore appear that for civil transport structural design is far advanced towards complete safety.

Controls.—It is a fighting pilot's wish to have an aeroplane wholly subordinate to his will even at the risk of danger to himself. Control is difficult to define in numerical form, especially as the manœuvres are rapid; it takes only a few seconds to get from a level keel to a vertical bank, and the pilot is far too busy to observe a stop watch. At the Royal Aircraft Establishment the idea was formed and developed of photographing one aeroplane from another. The cinema camera used was carried on one aeroplane which flew steadily along a straight level path; the film was driven by a small windmill. Directed towards a second aeroplane flying behind, any motion such as turning, rolling or looping could be photographed. The latest stage of the experiment is to use simultaneously a number of instruments bearing the undignified title of "Rats," which record the movement of the controls during the manœuvre. The work of reduction proved to be analytically difficult and has been circumvented by the use of a globe on which the solutions of spherical geometry present no difficulties. Given such a method of investigation it would be possible, even in a fighting scout, to assess the merits of any particular control in a definite numerical statement and so lay the foundation for the final design of the best systems.

Stable aeroplane.—Fig. 8 shows a speed record reproduced from an automatic apparatus attached to an aeroplane. A special clutch was provided by means of which the control column could be locked; the record begins with the aeroplane flying at 62 m.p.h. and the lock just put into operation. As the steady speed was then 73 m.p.h., the aeroplane, being stable, commenced to dive and gain speed. Overshooting the mark it passed to 83 m.p.h. before again turning upwards; there is a very obvious dying down of the oscillation and in a few minutes the motion would have become steady. The record shows that after a big bump the aeroplane controlled itself for more than 2 miles without any sign of danger.

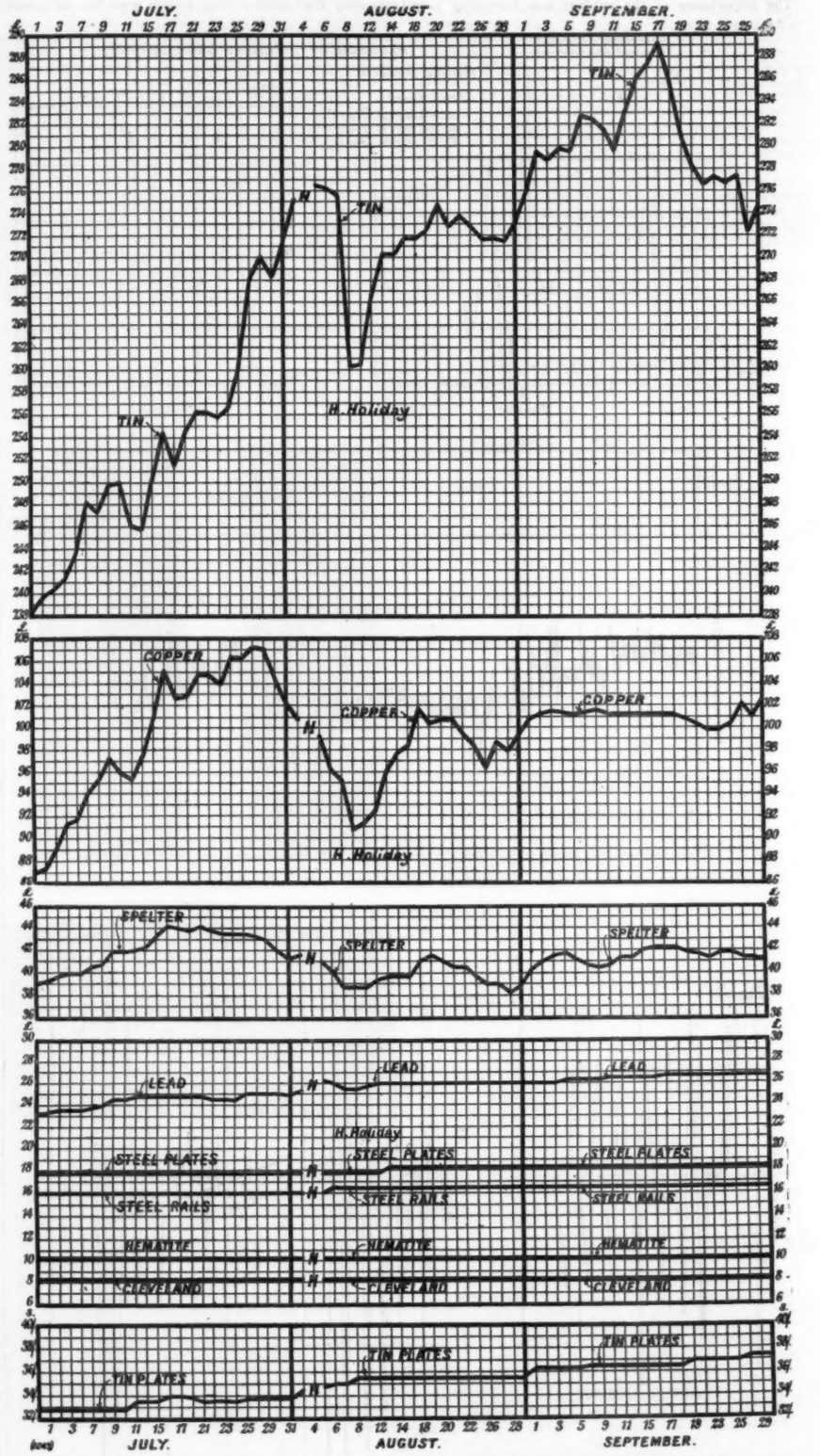
Unstable aeroplane.—The next record, Fig. 9, is very different and not so easily obtained since no pilot cares to let an unstable aeroplane attend to itself. No lock was provided, but by gently nursing the motion it was found possible to get to a steady flying speed with the control column against a stop. Once there the pilot held it as long as he cared to and the clock said that this was less than a minute. After a few seconds the nose of the aeroplane began to go up, loss of speed resulted and stalling occurred. Dropping its nose rapidly the aeroplane began to gather speed and get into a vertical dive, but at 80 m.p.h. the pilot again took control and resumed ordinary flight.

Further records.—As an aeroplane may be flown at different speeds it is necessary to examine the effect of speed on stability, and the next record, Figs. 10 to 12, show good stability for a modern aeroplane at speeds of 83 m.p.h. to 111 m.p.h. and for conditions more onerous than those of a locked control column. The records were taken by the equivalent of a pinhole camera carried by the aeroplane and directed towards the sun. The pilot started the record by putting the nose of the aeroplane down and then abandoning the control column. Big oscillations were produced which died down with considerable rapidity. All the records show marked damping, and without measurement it is difficult to detect any effect of speed. In the next record, Figs. 13 to 16, which is uncommonly interesting, the effect of speed is obvious. The upper diagram shows that at a speed of 10 m.p.h. and a height of 10,000 ft., the aeroplane is satisfactorily stable. During the period "*a*" the pilot did his best to fly level, whilst for "*b*" the aeroplane was left to its own devices and proved to be a good competitor to the pilot. At the end of "*b*" the pilot resumed control, put its nose down and abandoned the column to get the oscillation diagram which gives a measure of the stability. At a speed of 90 m.p.h. at 1,000 ft. the oscillation died down a little for the first few periods and then became steady. The stability in this condition was very small indeed and a reduction of speed to 70 m.p.h. was sufficient to produce hunting. Two records are shown, the more rapidly increasing oscillation being associated with climbing.

The oscillations so observed are calculable, and the effect of gusts in the natural wind are readily deduced from the oscillations observed in still air. It is to be hoped that the stability of the aeroplane will now receive the attention which has in the past been devoted to performance and has led to a British literature unparalleled in any other country of the world. It is easy to make an unstable aeroplane; it is not difficult to make a very stable aeroplane. On the other hand it needs considerable care to give an aeroplane a desired degree of stability.

Australia and Enemy Goods.—The Board of Trade have received through the Colonial Office, copy of a telegram from the Governor-General of the Commonwealth of Australia, stating that the Commonwealth Government is unable to modify its present policy towards deliveries containing more than 5 per cent. of goods of German or Austrian origin which have been, are, and will be, prohibited from entry into the Commonwealth. Prohibited goods landed in Australia will be liable to immediate forfeiture.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.



Note.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig iron. The prices given, in the case of steel plates, are for ship, bridge, and tank qualities, and those for steel rails are for heavy sections. The pig iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in Italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

AERONAUTICS.

129,688. W. and T. Avery, Limited, Birmingham, and H. Bolas, Brislington, Bristol. Seaplanes or Aeroplanes. (2 *Figs.*) November 26, 1917.—The invention consists of a seaplane or aeroplane characterised by the provision of a hinged fuselage, whereby the rear section of the fuselage, together with the tail of the machine, can be folded so as to lie adjacent to, beneath or within the main plane or planes. The fuselage is formed in two sections, a forward section 3 and a rear section 4, the sections being connected together at the one side by hinges and secured together upon the opposite side to that of the hinge by means of fish plates. When it is desired to fold the machine

Fig. 1.

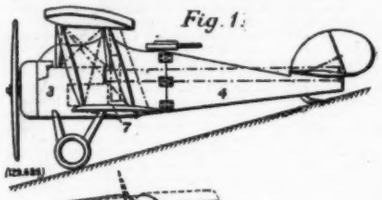
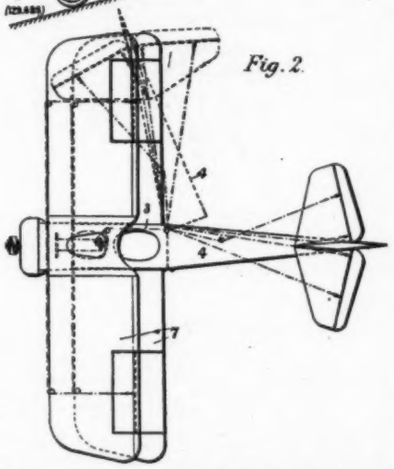
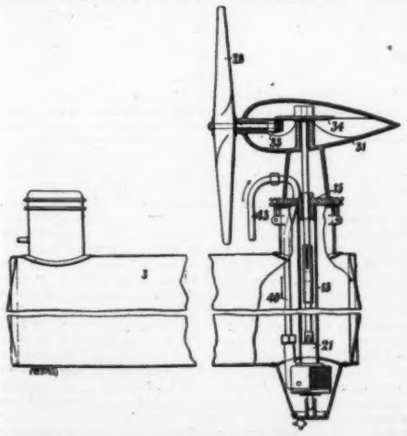


Fig. 2.



for carriage or transit, more especially for seaplanes when carried on the deck of a cruiser or other vessel, the fish plates are unfastened to release the connection at the one side of the abutting sections of the fuselage and the rear or tail section 4, together with the tail plane or planes, rudder and other appendages, is turned about the hinges until the rear section 4 and the tail are located adjacent to, beneath or within the main plane or planes 7 according to the type of aircraft to which this invention is applied. The folded position of the fuselage is seen by reference to the dotted line position of the rear section 4 in Fig. 2. (*Accepted July* 30, 1919.)

129,713. The Aircraft Manufacturing Company, Limited, Westminster, London, G. de Havilland, Hendon, London, and J. S. Chapman, Hendon, London. Aeroplanes. (1 *Fig.*) February 1, 1917.—This invention relates



to pumps and driving mechanism for delivering fuel from the main fuel supply tank to the carburettor or to the subsidiary supply tank on an aeroplane, or the like, and particularly to pumps of the gear wheel type, mounted within the main fuel supply tank and adapted to be driven through bevel gearing and a vertically extending spindle by an aeromotor mounted on the fuel supply tank. In a pump and driving mechanism therefor constructed in accordance with the present invention, the aeromotor 28 is carried by a gear case 31 of stream-like configuration enclosing the bevel gears 33, 34 and carried by a readily detachable cover plate 15 serving as a closure for an opening in the tank 3, whilst the outlet of the pump 21 is connected with an upright tube 40 which is separate from the pump-supporting tube 13 and which passes through the cover plate 15 and is furnished at its upper end with means for detachably coupling it to the fuel distribution pipe 43. (*Accepted July* 30, 1919.)

ELECTRICAL APPARATUS.

129,760. The Morgan Crucible Company, Limited, Battersea, London, and C. W. Speirs, Battersea, London. Electric Furnaces. (6 *Figs.*) June 14, 1918.—The invention relates to electrical furnaces of the class which employs a container composed of a material which itself constitutes the conductor through which the electric current is caused to flow and which is designed to be heated by a three-phase current. Accord-

Fig. 1.

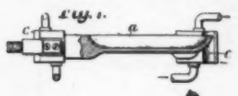
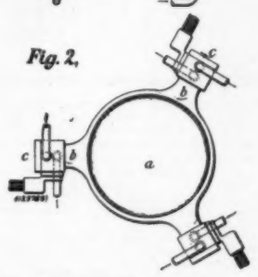


Fig. 2.



ing to this invention, the container *a*, which is constructed of graphite and clay or like mixture, is made in the form of a circular or approximately circular dish or hearth, and in order to reduce heat losses to a minimum, it has formed integral therewith, during the moulding operation, three lateral extensions *b* to which accurately fitting water-cooled terminals *c* are applied. (*Accepted July* 30, 1919.)

129,889. W. Chilton, Barrow-on-Soar, Loughborough, and The Brush Electrical Engineering Company, Limited, Loughborough. Turbo-Generator Plants. (4 *Figs.*) October 23, 1918.—This invention relates to a turbine and electrical generator plant comprising a high-pressure double rotation turbine driving two generators and one or two low-pressure turbines each driving one or two generators and driven by the exhaust steam from the high-pressure turbine. The drawings show a high-pressure double rotation Ljungström turbine con-

Fig. 1.

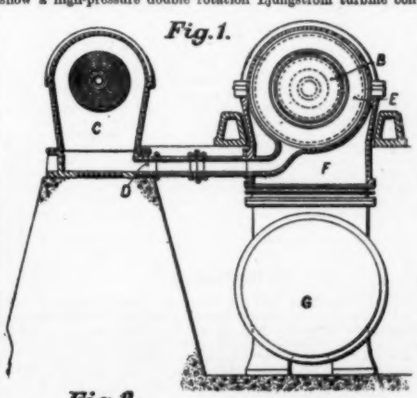
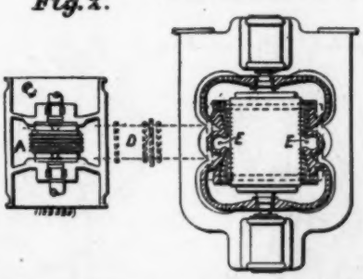


Fig. 2.

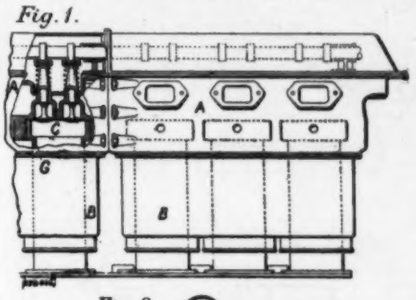


nected up in series with one ordinary low-pressure double-flow turbine. High pressure steam is supplied to the Ljungström turbine in the usual manner and is not indicated on the drawing. A is the Ljungström high-pressure double rotation turbine, B the ordinary double flow low-pressure turbine. The steam in the high-pressure turbine is exhausted into the exhaust chamber C and from this chamber the steam passes through the supply pipe D to the steam inlet chamber E of the low-pressure turbines. Here the steam flows through the blading both ways finally exhausting into the low-pressure exhaust chambers F, from which it passes into the condensers G. The generators are not illustrated. (*Accepted July* 30, 1919.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

129,685. Wolseley Motors, Limited, Birmingham, and A. A. Remington, Birmingham. Internal Combustion Engines. (2 *Figs.*) November 24, 1917.—This invention relates to multi-cylinder internal combustion engines of the type in which the barrels of the cylinders are formed of thin metal, enlarged internally at their upper or outer ends, and fixed into castings or breech-ends which are integral with their water-jackets and have the induction and exhaust passages formed therein, and carry the valves. Each set of three cylinders has a common jacketted head A and a common cylinder jacket B, the heads A being bolted together. The heads are cast in a material which has a high heat conductivity compared with that of iron or steel and the upper or outer ends of the cylinder barrels C are formed open so that the flame and hot gases within the

Fig. 1.



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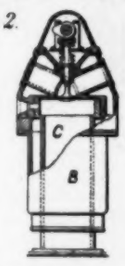


cylinders are directly exposed to the metal of high heat conductivity of the cylinder heads, the heat being rapidly conveyed thereby to the water within the head jacket. The diameter of the upper or outer ends of the cylinder barrels is enlarged substantially beyond that of the portions of the barrels within which the pistons travel, and valves of large diameter, which this enlargement of the diameter of the outer ends of the cylinders makes possible, are used with a view to ensure maximum volumetric efficiency. The rapidity with which the heat is conducted into the cooling water in the head jacket ensures efficiency in cooling the valves and their seats, thereby facilitating the ure of larger valves than usual in valve arrangement of this type compared with the diameter of the cylinders. (*Accepted July* 30, 1919.)

129,715. D. Napier and Son, Limited, Acton, London, and A. J. Rowledge, Acton, London. Internal Combustion Engines. (2 *Figs.*) December 5, 1917.—This invention relates to valve gear for internal combustion engines. According to this invention, the faces of the cams C1, C2, D1, D2 on the overhead shafts C, D are lubricated by the excess of oil from the bearings E1, E2 of the cam shaft or shafts which is allowed to flow from the ends of each bearing on to the faces of the adjacent valve tappet discs A, A1, B, B1. A bearing E1 or E2 for an overhead cam shaft

Fig. 1.

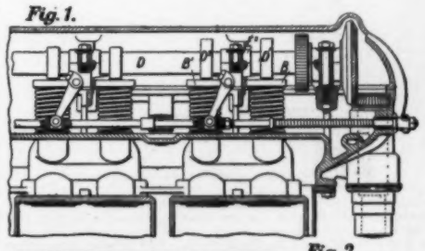
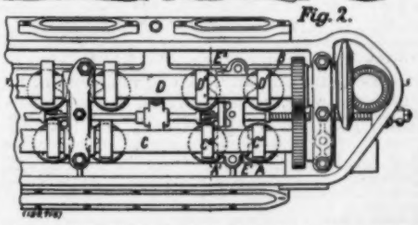


Fig. 2.

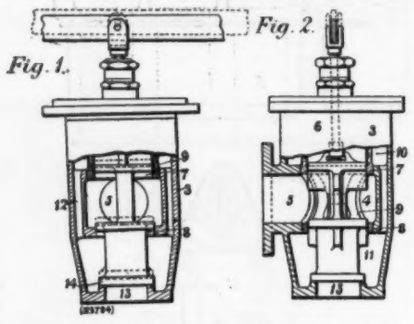


is situated on the head of each cylinder and in such a position relatively to the cams and tappet discs that oil escaping from the cam shaft bearings will pass therefrom on to the tappet discs and serve to lubricate the cam peripheries. Each bearing is thus positioned between the two cams operating respectively the inlet and exhaust valves, the ends of the bearings being so arranged as to overhang the faces of the tappet discs. The oil exuding from the ends of each bearing falls directly on to the tappet discs or is delivered thereto by suitably shaped guide pieces or lips provided at the ends of the bearings. Oil is

supplied under pressure to the cam shaft bearings from the main lubricating system, and as this supply is conveniently arranged to be more than sufficient to meet the actual needs of these bearings the surplus passes on to the tappet discs and supplies the necessary lubricant between these discs and the peripheries of the cams. By thus disposing the camshaft bearings on the cylinder heads instead of between the cylinders as in previous practice it becomes possible to shorten the length of the camshaft and also to place these bearings nearer to the load inasmuch as in the present improvement each bearing lies adjacent to two cams. (*Accepted July* 30, 1919.)

HYDRAULIC MACHINERY.

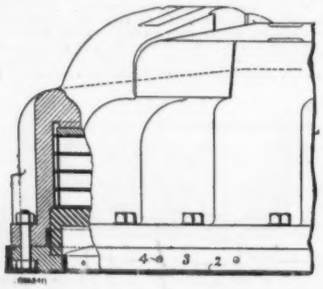
129,784. W. and T. Avery, Limited, Birmingham, J. J. Burrows, Birmingham, and E. Walters, Birmingham. Valves. (2 *Figs.*) July 13, 1918.—This invention comprises a valve for controlling liquids having in combination a double-seated plug lift valve and a disc valve located below said plug lift valve all formed or mounted on the same valve spindle and operable by the rise and fall of the said spindle, the said valves being mounted within a multi-chambered valve casing. The valve casing 3 has an inner valve chamber 4 into which the liquid supply enters through a port 5 disposed parallel to the valve spindle 6. This inner chamber 4 has outlets 7, 8 at the top and bottom, both outlets being controlled in unison by a plug lift valve 9. Above and below the inner chamber 4 are two further valve chambers 10, 11 connected by a substantially annular channel 12 which surrounds the inner chamber 4. The



incoming liquid passes through the port 5 into the inner chamber 4 and thence to the upper and lower chambers 10, 11 when the plug lift valve 9 is open, the liquid from the upper chamber 10 joining the liquid in the lower chamber 11 through the said channel 12. The lower chamber 11 has an outlet 13 at its lower end controlled by a disc valve 14 formed at the bottom end of the valve spindle, the said disc valve resting upon a valve seating formed around the outlet. The arrangement of the two valves 9, 14 is such that the valve 9 closes the inner chamber 4 before the disc valve 14 has contact with its seating whereby the supply of liquid passing through the valve is first of all cut off by the valve 9 and the liquid which has passed into the upper and lower chambers 10, 11 has time to be discharged through the outlet 13 before the disc valve 14 cuts off the outlet 13 of the lower chamber 11. (*Accepted July* 30, 1919.)

LIFTING AND HAULING APPLIANCES.

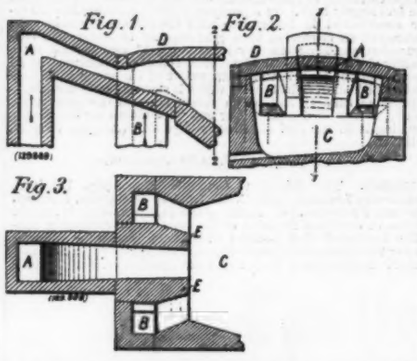
129,841. Allen West and Co., Limited, Brighton, and F. N. Pickett, Hove. Transporting Magnets. (1 *Fig.*) August 9, 1918.—This invention has reference to power magnets specially adapted for moving heavy sheet metal plates without actually lifting them. The present invention consists broadly in providing means for increasing the frictional resistance between



the magnet and the plate by providing the magnet with a surface which, when the magnet is energised, will have a high co-efficient of friction. In carrying the invention into practice, the outer pole and/or other parts of the magnet is or are provided with a covering 2 of some frictional material, such as a woven material comprising brass wire and asbestos, which material will be found to have a high co-efficient of friction. (*Accepted July* 30, 1919.)

MINING, METALLURGY, AND METAL WORKING.

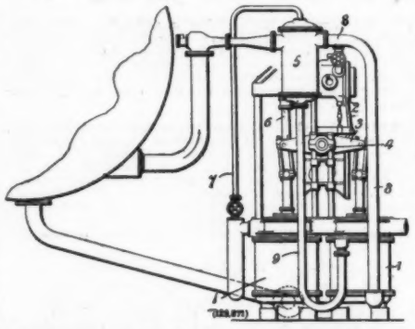
129,869. W. J. Mellersh-Jackson, London (*Società Anonima Ch. M. Stein and Co., Rome, Italy*). **Open Hearth Furnaces.** (3 *Figs.*) September 19, 1918.—This invention relates to open hearth regenerative furnaces of the Siemens or Martin Neinkoff types in which the air ducts are arranged at the side of a gas duct. The invention consists in providing a regenerative open hearth furnace of the type referred to and in which an air duct or air ducts is or are disposed at each side of the gas duct wherein the air and the gas are constrained to flow to and mix on the furnace hearth, from their respective ducts, by an independent short separating and common extension. A indicates the passage for the gas, B the passage for the air, C the hearth, D the roof of the furnace and E partitions forming extensions of the ducts and separating the air from the gas until their arrival into the furnace from the ducts. The plane of the roof D of the furnace is shaped to run smoothly into the plane of the duct so that there are no edges, the junction being effected behind the mouth of the ducts and being supported externally of the gas duct by the rear walls of the air ducts as clearly illustrated in Fig. 3. From the arrangement of the passages A and B, it results that the mixing of the air with the gas takes place on the furnace hearth, and since the roof of the gas flue does not reach the hearth itself, the said roof is protected from the intense heat of the flame. Obviously the result will be that only the two short portions of the partitions



E will wear and burn out very quickly, but on account of their location, it will be easy to repair them without loss of time and without interrupting the working of the furnace. (*Accepted July* 30, 1919.)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

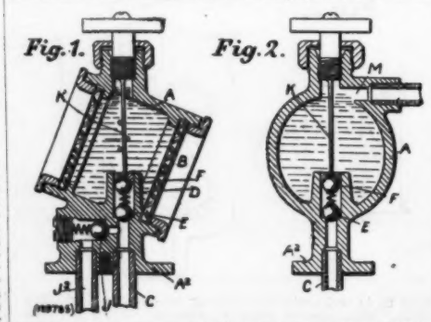
129,871. D. B. Morison, Hartlepool. Steam Condensing Apparatus. (1 *Fig.*) September 20, 1918.—In condensing apparatus in which air is withdrawn from a main condenser and delivered to a receiver or auxiliary condenser by a steam jet, the receiver is rigidly disposed in a fixed predetermined relation to the usual pump barrels thus enabling pipe connections being standardised to conform to specific conditions. 1 designates the pump barrels and 2 the steam cylinder, the pump piston rods being connected by a beam 3 pivoted to the cross head 4 in the usual manner. The receiver or auxiliary condenser 5 is arranged alongside the steam cylinder 2 in a definite position and is supported by means of columns 6 similar



to the columns supporting the steam cylinder, the whole forming a structure which admits of the connection from the receiver or auxiliary condenser 5 being designed and standardised to conform to specific conditions. It will be seen that by this arrangement the connection pipes 7 through which condensate is delivered to the receiver or auxiliary condenser 5, and the pipes 8 and 9 through which air and water, respectively, are withdrawn can be of a standard size and form with the advantages that not only are the conditions for efficient working automatically established, but while the minimum of material can be employed, spare parts can be provided and readily substituted in case of breakage or damage. (*Accepted July* 30, 1919.)

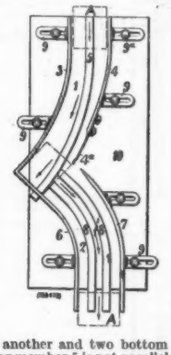
MISCELLANEOUS.

129,785. Douglas Motors, Limited, Kingswood, Bristol, S. L. Bailey, Kingswood, Bristol, and W. W. Douglas, Kingswood, Bristol. Sight-Feed Lubricators. (4 *Figs.*) July 13, 1918.—This invention relates to sight-feed lubricators of the type in which the oil travels upwards under pressure through a column of water. According to this invention, oil is admitted at the bottom of a barrel-shaped body with a flat



transparent face at one or both ends and escapes at the top. The sight-feed chamber A consists of a barrel-shaped member, the ends of which are provided with glass windows B fixed pressure tight therein. The chamber is provided with a base A2, which is so disposed that the axis of the chamber is inclined to the horizontal, for example, by about 30 deg., when the chamber is mounted in position. The oil is supplied by a pressure pump (not shown) and enters the chamber A by a conduit C. The conduit communicates with a nozzle D. Within the nozzle are two ball-valves, the lower E of which seats downwardly to form a non-return valve to the oil conduit, and the upper F seats upwardly to close the outlet orifice and constitute the regulating-valve. A coil spring between the two valves presses each on its seating. Beneath the lower valve a lateral conduit J2 communicates with an overflow pipe to the oil tank by way of a spring loaded non-return ball valve J constituting a bye-pass or relief valve. Projecting into and having threaded connection with the upper part of the chamber A immediately above the nozzle D is a vertically disposed spindle K, the lower end of which bears upon the upper ball valve F in the nozzle to regulate its opening at will. At the highest part of the interior of the chamber is a lateral outlet M to which is connected the oil-outflow conduit. In use the chamber is filled with water to a height just below the level of this outflow conduit M and the water is introduced therein by removal of the screwed spindle K. The action of the sight-feed lubricator is as follows:—With the regulating valve F closed, oil delivered by the pump cannot enter the sight-feed chamber but returns to the tank by way of the bye-pass valve and overflow conduit J, J2. On opening the regulating valve by means of the spindle K, oil issues from the nozzle D and rises through the water as a series of beads or in a continuous stream. As the oil rises towards the outflow pipe it clings to and is guided by the spindle K. (*Accepted July* 30, 1919.)

129,479. A. H. Guinness, London. Can-making-Machines. (1 *Fig.*) July 30, 1918.—This invention of improvements in connection with can-making machines has relation to apparatus by which the partly made can is caused to turn through an angle as it passes between machines in the course of its manufacture. The runway comprises an upper portion 1 and a lower portion 2. The several parts constituting a runway are mounted on a board 10, and this board is arranged in a sloping position between the first machine and the foot of the elevator. The two portions are thus in the same plane and are furthermore arranged at an angle to one another and are curved in the direction of their lengths. The can A is delivered from the first machine to the upper end of the portion 1 and slides down this portion in an end-on position; at the junction of the portions 1, 2 the leading end of the can comes into contact with the upper end of the portion 2, its further end on progress is stopped and it comes to rest with its full length or side opposite the upper end of, and parallel with, the second portion 2, down which it proceeds to slide or roll side on to the foot of the elevator by which it is raised to the second or other machine in which a further step or further steps in its manufacture is or are effected. The portion 1 comprises side guiding members 3, 4 arranged parallel with one another and a bottom guiding member 5. The portion 2 likewise comprises side guiding members 6, 7, arranged



parallel with one another and two bottom guiding members 8 The bottom guiding member 5 is not parallel with the side guiding members 3, 4, but is so arranged that it gradually approaches, in the direction of its length, the side guiding member 4. The bottom guiding members 8 are parallel with one another and with the side guiding members 6, 7. The portion 1 has an additional or upper guiding member (not shown) which comes directly above the bottom guiding member 5 and which extends as far as the junction of the portions 1, 2. The side guiding members 3, 4 are adjustable towards and away from each other and the upper guiding member of the portion 1 is so mounted on the base or carrying board 10 that it may be adjusted towards or away from the side guiding members 3, 4 and the bottom guiding member 5 in a vertical direction so as to accommodate cans of various diameters. The side guiding members 6, 7, are also adjustable towards and away from each other and the side guiding member 4 is provided at its lower end with a spring member or finger 4a, which is adjustable thereon longitudinally, so as to accommodate cans of various lengths. The side guiding members 3, 4 and 6, 7 are provided with slotted lugs or brackets 9 and the base or carrying board 10 is provided with studs or bolts 9a which pass through the slots of the lugs or brackets and on which they are adjustable. The side guiding member 3 of the portion 1 is unitary with the side guiding member 6 of the portion 2. (*Accepted July* 23, 1919.)

Calculation of Antenna Capacity.—The Bureau of Standards has, in its Circular No. 74, of 1918, made an addition to the literature on the capacity of antennæ for radiotelegraphy. One of the first comprehensive researches on this subject was published by Professor G. W. O. Howe in 1914, when he dealt with flat-top antennæ; later he added formulæ for umbrella antennæ. All these formulæ and also those of L. Cohen, 1915, require laborious calculations. In the Journal of the Washington Academy of Sciences, of August 19, W. Austin, of the United States Radio-Research Laboratory, shows that the capacity of an antenna which is not too elongated in shape and has its wires not too widely spaced, can very approximately be represented by the formula: $c = (4\sqrt{a} + 0{\cdot}88\ a/h)10^{-9}$, where c is the capacity in microfarads; the area in square metres and h the mean height in metres. When the length l exceeds the breadth b by more than eight times, an elongation factor has to be added to the formula, which passes into: $c = (4\sqrt{a} + 0{\cdot}88\ a/h)\ (1 + 0{\cdot}015\ l/b)\ .\ 10^{-9}$. The first empirical formula is really the sum of the usual expressions for the capacity of a disc in space and that of a two-plate condenser, disregarding edge effects. The paper contains tables on the capacities of antennæ of various shapes, calculated and observed; the agreement is satisfactory.